SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • December 23, 1958

The way of a scientist

Is there such a thing as 'the scientific method'? No, says the author, and talking about it may lead students to a number of serious misconceptions

■ Very often a student writing up his "experiments" or the demonstration experiments is required to follow a rigid format with headings such as: Problem, Apparatus, Method, Observations, Conclusion. This may lead to a rather serious misconception of how a scientist works and — yet more serious — to a misunderstanding of the meaning of what is called "scientific method." Strangely enough, the scientist rarely if ever uses that term. The reason is simple: there is no such thing. However, we do find the term "scientific method" in our general science, biology, chemistry, and physics textbooks, and so must come to grips with it. Percy Bridgman, Nobel Prize winner in physics and a thinker in this field, summed up the process in a few words: "The scientific method as far as it is a method is nothing more than doing one's damnedest with one's mind, no holds barred."*

He further elucidated this thought in a magazine article that has been reprinted in *Reflections of a Physicist*, Philosophical Library, 1950:

"It seems to me that there is a good deal of ballyhoo about scientific method. I venture to think that the people who talk most about it are the people who do least about it. Scientific method is what working scientists do, not what other people or even they themselves may say about it. No working scientist, when he plans an experiment in the laboratory, asks himself whether he is being properly scientific, nor is he interested in whatever method he may be using as *method*. When the scientist ventures to criticize the work of his fellow scientists, as is not uncommon, he does not base his criticism on such glittering generalities as failure to follow the 'scientific method,' but his criticism is specific, based on some feature characteristic of the particular sit-

*P. W. Bridgman, "On Scientific Method," *The Teaching Scientist*, Dec., 1949, p. 23.

January 20 issue ends first semester

Because of the Christmas vacation period, the next issue of Science World will be dated January 20. It will reach schools on or before January 13, and it is the last issue of the first semester.

If your classroom subscription is for the school year, the second semester's issues (starting with February 10) will, of course, reach you automatically. However, if you wish to revise the number of copies ordered we should appreciate hearing from you as soon as possible.

If your subscription is for the first semester only, now is the time to renew. If you wish, you may later revise the number of copies ordered. Naturally, you will be billed only on the basis of your final order. A prompt renewal guarantees uninterrupted delivery of SW to your classroom.

uation. The working scientist is always too much concerned with getting down to brass tacks to be willing to spend his time on generalities.

"Scientific method is something talked about by people standing on the outside and wondering how the scientist manages to do it. These people have been able to uncover various generalities applicable to at least most of what the scientist does, but it seems to me that these generalities are not very profound and could have been anticipated by anyone who knew enough about scientists to know what is their primary objective. I think that the objectives of all scientists have this in common — that they are all trying to get the correct answer to the particular problem in hand. This may be expressed in more pretentious language as 'the pursuit of truth.' Now if the answer to the problem is correct, there must be some way of knowing and proving that it is correct — the very meaning of truth implies the possibility of checking or verification. Hence the necessity for checking his results always inheres in what a scientist does. Furthermore, this checking must be exhaustive, for the truth of a general proposition may be disproved by a single exceptional case. A long experience has shown the scientist that various things are inimical to getting the correct answer. He has found that it is not sufficient to trust the word of his neighbor, but, if he wants to be sure, he must be able to check the result for himself. Hence the scientist is the enemy of all authoritarianism. Furthermore, he finds that he often makes mistakes himself and he must learn how to guard against them. He cannot permit himself any preconception as to what sort of results he will get, nor must he allow himself to be influenced by wishful thinking or personal bias. All these things together give that 'objectivity' to science which is thought to be the essence of the scientific method.

"But to the working scientist himself all this appears obvious and trite. What appears to him as the essence of the situation is that he is not consciously following any prescribed course of action, but feels complete freedom to utilize any method or device whatever, which, in the particular situation before him, seems likely to yield the correct answer. In his attack on his specific problem he suffers no inhibitions or precedent or authority, but he is completely free to adopt any course that his ingenuity is capable of suggesting to him. No one standing on the outside can predict what the individual scientist will do or what method he will follow. In short, science is what scientists do, and there are as many scientific methods as there are individual scientists."

Perhaps the last line of the quotation from Bridgman's work best drives home the point of this article.

As science teachers, we ought to discourage the idea that each morning a scientist walks through his lab doors and says, "Now, what shall I discover today?" Perhaps we ought to also point out that each discovery, rather than bringing things to a conclusion, simply opens the doors to fifty or a hundred new problems that were not apparent before. One simple way to state this is: "A scientist's work is never done." Each new discovery in modern biology or physics or chemistry opens up a vista of new questions to put to nature.

Perhaps it's an oversimplification to say that a scientist knows how to ask the correct question of nature. Frequently the work starts with observation of phenomena, and the exact problem to be investigated is not immediately understood. In other words, we cannot assume the straightforward approach found in students' notebooks and workbooks. In modern scientific language, when theoretical work is done — in distinction to laboratory investigation — the scientist works with a model. This is a mental model. The model when tested may not completely fit reality. When it breaks down it is discarded, and a better model replaces it. Sometimes the model is applicable to only a limited area.

Perhaps it is easiest to say that the way of a scientist is to find out how the world operates. Once one idea is developed, it leads to another idea and then still another. Science corrects itself, it does not merely accumulate. The scientist tries to solve the jigsaw puzzle of how the world operates — from the inside of the atom to galaxies in outer space. Choosing the correct operation to put the question to nature is extremely important. Once the answer seems to have been attained, it is checked by others who repeat the same or more sophisticated operations.

Getting this general philosophy across to the students is not easy. Maybe one small step toward it in the classroom or laboratory is the elimination to some degree of the extremely formal steps of the "scientific method" in our teaching. Our aim: to show that there is no end to scientific methods.

— Alexander Joseph

YOUNG SCIENTISTS

Teachers are urged to have their students submit write-ups of interesting projects or experiments they have done. If printed in Science World, full credit will be given to the student, the school, and the teacher. In addition, the student will receive $15. Contributions should be addressed to Science Project Editor, Science World, 575 Madison Avenue, New York 22, N.Y. Students should be reminded that by submitting their ideas they can do a service to thousands of other students.

MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

Ants, ants, ants

BIOLOGY TOPICS: insects, behavior, symbiosis
GENERAL SCIENCE TOPICS: insects

This fascinating article gives biology and general science students a rather complete over-all view of the social world of the ant. Ant nutrition, behavior, senses, and symbiosis are only a few of the high points that lend themselves to articulation with the regular classwork in these areas. Students will want to learn the scientific terms that are explained in the article.

Discussion questions

1. Why are ants called social insects?
2. What determines the future role of an individual ant?
3. Why do some ants need slave ants?
4. What is a worker ant's life span?
5. How do ants find food?
6. Which ants raise their own "crops"?
7. What is an ant "death march"?

Experiments and projects

1. Build a simple ant house between two panes of glass by sealing together the frames of two small windows. Make a small opening that can be closed by a wood plug in the top of the frames. Add sand, then ordinary, non-biting ants. Food can be supplied regularly through the opening. (If you prefer, you can buy a commercial ant house.) Have students observe the ants' activities through the glass.
2. Test the ability of ants to return to sugar after you have erased the scent by drawing first your finger and then a piece of cotton across the ant path.

Science leads the way toward peace

TOPIC FOR ALL SCIENCE CLASSES: science in international affairs

This inspirational article is appropriate to tne Christmas season. It can buoy up the hopes of the pessimists among us and among students about the future course of peace. The author points out the advances in international scientific co-operation that have taken place as well as those that are occurring at present. Dr. Wendt shows us that the future of world peace may lie in the direction of international scientific work rather than the usual political efforts. In the article, he points out the many fields, in addition to those in the IGY program, in which scientific co-operation is providing fruitful results on a wide scale. The articles can be used as the basis of a forum discussion in which both science and social studies classes can take part.

Discussion questions

1. Why is scientific agreement easier to obtain on an international scale than political agreement?
2. In which scientific fields is large-scale international co-operation now taking place?
3. How has the intrusion of politics by the Russians helped make international atomic control difficult?

Smaller than the atom

PHYSICS TOPICS: sub-atomic particles, cosmic rays
CHEMISTRY TOPIC: anti-matter
GENERAL SCIENCE TOPIC: atomic energy

This is the conclusion of a two-part article by Isaac Asimov. It contains the kind of material that is almost completely missing from even the latest editions of high school textbooks in physics, chemistry, and general science. The tabulation of sub-atomic particles provides a graphic picture of today's knowledge of the atomic nucleus. At the same time, the author introduces the reader to the strange world of anti-matter. This kind of article can update science teaching and provide great classroom motivation.

Discussion questions

1. What are the main differences among sub-atomic particles?
2. Which particles belong to the anti-matter group?
3. How do anti-particles differ from ordinary particles?
4. What happens when a proton meets an anti-proton?

Experiments and projects

1. Build the cloud chamber described in September 25 SCIENCE TEACHER'S WORLD. Observe it long enough to see cosmic rays.
2. Build the simple Geiger counter described in November 11 *STW*. Cover the tube with sheet lead, and use it to detect cosmic rays.
3. If possible, borrow the Bell System TV film, "The Strange Case of the Cosmic Rays," and show it. This film, like others in the Bell Science Series, is available on loan to schools without charge. Contact your local Bell Telephone Business Office.

An hour of cloud life

GENERAL SCIENCE TOPIC: cloud formation
PHYSICS TOPICS: condensation and evaporation
EARTH SCIENCE TOPIC: meteorology

This unusually striking picture article is one that can contribute more to an understanding of cloud formation than the usual photographic collection of "types of clouds." The pictures, taken at intervals, show the growth and dissipation of clouds. Students may want to repeat the same photographic experiment at home by following the techniques described by the author. If slide film is used, the slides can be projected.

Discussion questions

1. Why is it sometimes difficult to identify a cloud type?
2. What are the most common types of clouds present in your locality?
3. What physical changes are taking place in a cloud?

Projects and experiments

1. Using a cloud filter, make your own sequence of cloud pictures.
2. Take motion pictures of cloud formations, using a sky filter to emphasize the clouds.
3. Take a picture of the clouds in one part of the sky at the same time each morning. At the end of a year, see if there is any seasonal pattern of cloud types.

The legacy of the alchemist

CHEMISTRY TOPICS: alchemy, history of chemistry
GENERAL SCIENCE TOPICS: elements and compounds

Students should be intrigued by this thorough coverage of the role of the alchemists in the development of chemistry. In the unscientific search for the philosopher's stone, the alchemists learned a great deal about simple inorganic reactions. It was at the end of the eighteenth century, after Lavoisier's work, that chemistry became a science. Nevertheless, most simple reactions, acids, bases, and salts were already known by that time. Both chemistry and general science students can appreciate this rich but unscientific historical background of modern laboratory chemistry.

Discussion questions

1. Why can't alchemists be called scientific chemists?
2. What chemical knowledge did alchemists bequeath to us?
3. Why was alchemy a hazardous profession?

Farming for antibiotics

BIOLOGY TOPICS: molds and bacteriology
GENERAL SCIENCE TOPIC: antibiotics

This article is unusual in that students can almost immediately attempt to grow and test antibiotics obtained from the soil. All instructions are provided. The technique is carefully worked out. In units on bacteriology and antibiotics, this article can serve as the basis for classroom laboratory work or for demonstration work by students for the benefit of the class. In addition, it may serve as excellent material for biology club programs or for development into a science fair exhibit.

Discussion questions

1. How are the antibiotic-producing microorganisms grown?
2. How do you separate one type of microorganism from another?
3. How do you test for the inhibition of bacterial growth by an antibiotic?

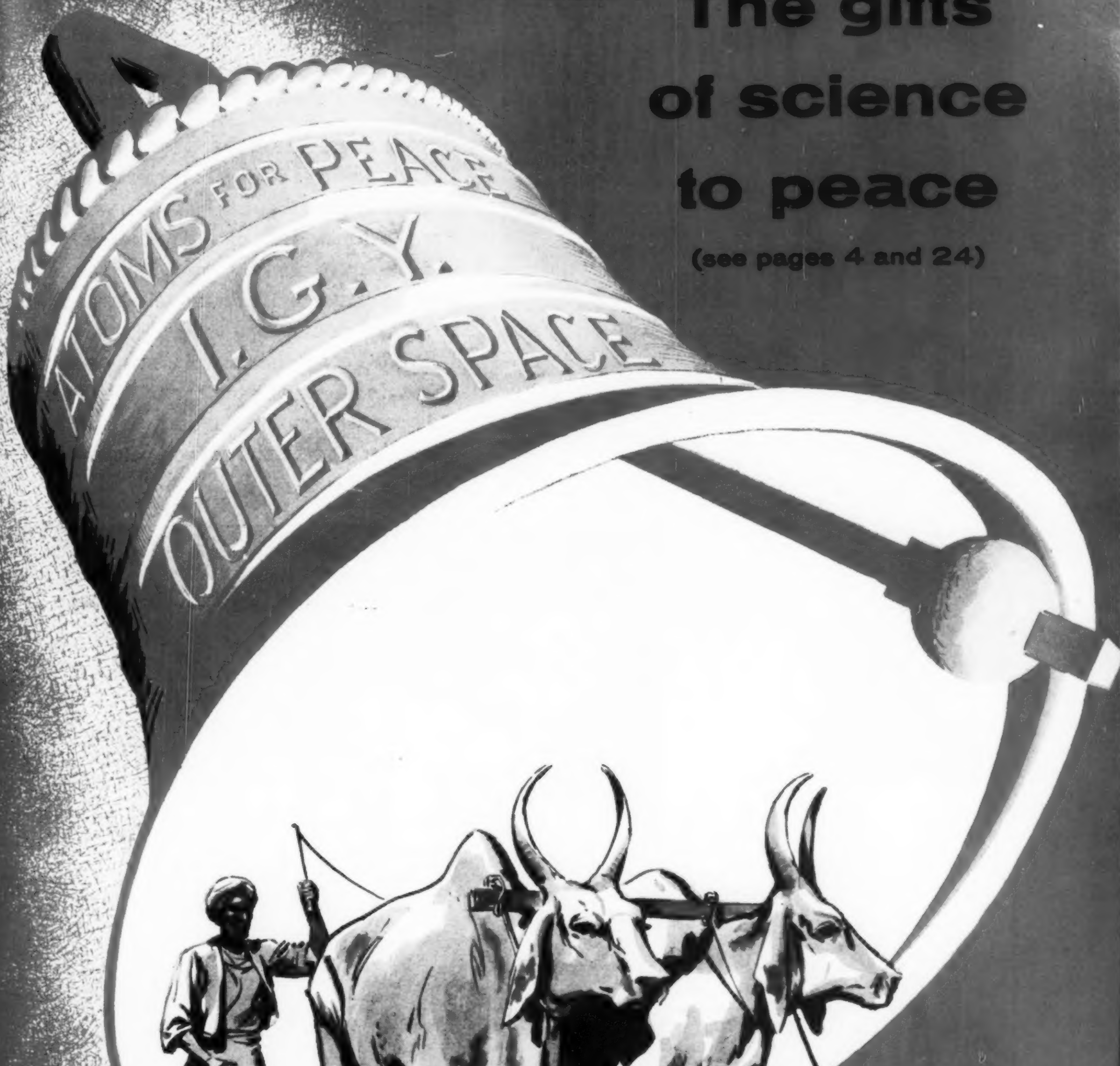
EMBER 23, 1958

SCIENCE WORLD

E SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

The gifts of science to peace

(see pages 4 and 24)



SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

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If your subscription expires with the January 20 issue, be sure to renew now. Don't risk missing any issues in the spring semester, 1959.

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Features

Departments

Cover by Lee Ames

To all of you
and your families
best wishes for a
Merry
Christmas
and
Happy
New Year

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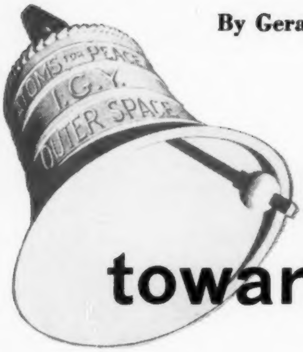
By Gerald Wendt



Science leads the way toward peace

■ The International Geophysical Year has done much for geo-friendship and geo-peace. Constant co-operation, day and night, between scientists of many nations — in the antarctic, in oceanic expeditions, in weather observations, and, above all, in collating data from the satellites — has obliterated national boundaries in the common cause. More than that, it has created an atmosphere of peaceful accomplishment for humanity as a whole, an air of truth-seeking instead of propaganda. Men now see science leading the way toward permanent peace.

"The area of conflict has been somewhat reduced," Secretary-General Dag Hammerskjold reported to the United Nations after a committee of scientists from East and West agreed at Geneva in August that the detection of nuclear bomb tests is feasible at a distance (SW, October 14). In these words, he announced a major contribution of science to peace. The end of nuclear bomb tests was in sight.

In his annual report, Hammerskjold went on to suggest that "further progress might be made in separating the political from the non-political elements, thus helping to reduce further the area of disagreement." He proposed as the next task for science "technical studies in relation to security from surprise attack." If this goes on, statesmen will deal in facts instead of words. This is the new climate of diplomacy.

Then, in September — again at Geneva — the major governments of the world took another large and surprising step toward the scientific attitude. They announced at the Second United Nations Conference on the Peaceful Uses of Atomic Energy that they had agreed to abolish all secrecy in their researches on thermonuclear power, hence on the fusion reaction that would use a form of hydrogen called deuterium as atomic fuel. Now everyone can follow the development of what promises to become one of the greatest boons to mankind: unlimited cheap power from the waters of the sea. It was a political decision, but it was made in the new climate of international science. The 5,000 scientists from 67 nations assembled at Geneva applauded and went on at once to discuss the next step: direct co-operation combining the skills and resources of groups of nations to create a new world resource. This is realistic and creative, in striking contrast with the bluster of politics.

But the fundamental problem remains — the prevention of war. It cannot be achieved by treaties, as history has shown time and again. It could be done by gradual disarmament but that, too, requires more than agreements and promises. It needs confidence on each side that the other is living up to the agreements. How can that confidence be established? That question separates the non-political from the political and opens the door to science once more.

The committee of scientists reported in August that secret testing of nuclear bombs would be virtually impossible if a system of 180 inspection stations was established all over the world. Immediately after, President Eisenhower announced that the United States would test no bombs after October 31 and would refrain for a year — and year-by-year thereafter — provided such an inspection system was established and "satisfactory progress" was made towards arms control. Great Britain concurred. The Soviet Union had already abolished bomb tests in March. Thus, in a wave of optimism, the stage was set for another committee to meet at Geneva in November. Its purpose: to arrange the details of a world-wide inspection network under international control that would report any nuclear explosions.

The delegates of the U.S.S.R., led by Semyon K. Tsarapkin, of Great Britain, with David Ormsby-Gore as leader, and of the United States, under Ambassador James J. Wadsworth, have been negotiating since early November but at this writing without results. The United States insists on a workable inspection system before abandoning nuclear arms; the U.S.S.R. wants nuclear disarmament first, agreement on inspection later. The U.S.S.R. thus seems to have lost sight of the purpose of the meeting,

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Illustrated by Robert Shore

1958

namely, to create mutual confidence. It has, temporarily at least, abandoned the solid scientific approach and has returned to political maneuvering. But that route is devious. So the conference may yet succeed in throwing the first tenuous bridge across the abyss between the two countries and thus in opening the first road to disarmament and to peace. If so, it would be a historic Christmas gift of science to the world.

Surprise attacks

Meanwhile, another international group began meetings on November 10, also at Geneva. Its purpose: exploration of technical means for preventing surprise attacks or of removing the element of surprise from any possible attack. Ten nations are involved: the United States, Canada, Great Britain, France, and Italy on the one side, with the Soviet Union, Poland, Czechoslovakia, Rumania, and Albania on the other. The Western powers assumed that these talks were to be strictly technical — that is, devoted solely to discovering and evaluating the various scientific or engineering devices that would eliminate the element of surprise. In this way they would parallel the studies of the scientists who met last August on the reliability of means for detecting nuclear bomb tests.

However, the Soviet delegation is headed by Vassily V. Kuznetsov, a First Deputy Foreign Minister, who revealed a totally different concept and proposed limiting the discussions to disarmament as such, namely to the abolition of nuclear weapons, the liquidation of military bases on foreign soil, and cuts in conventional weapons and forces. The head of the U.S. delegation, William C. Foster, executive vice-president of the Olin Mathieson Chemical Corporation, was unprepared for such topics and could not accept them. So at this writing the two sides are speaking of two totally different subjects which, to put it mildly, is unscientific. Indeed, it is an object lesson in the difference between the scientific and the political approaches to world problems.

In both Geneva meetings it is thus evident that the atmosphere of science does not yet permeate the policy levels of the Soviet government. Complex and difficult problems are still attacked with blustering demands, instead of by separating them into simpler problems and achieving — step by step — a basis of reliable and convincing facts. But the meeting may yet accomplish that very purpose.

Professor Eugene Rabinowitch of the University of Illinois has put it this way (*Bulletin of the Atomic Scientists*, October, 1958): "The question is, are the nations of the

world about to learn that the way to achieve their common aims is to break their mutual problems into technically significant packages and entrust their scientific experts with finding solutions which would provide the maximum objective satisfaction to all? ... This new approach to the fundamental problems of the arms race and world security ... may be a more radical innovation than the political leadership of the major nations is now willing to contemplate, despite the disastrous experience of traditional diplomacy in the past ten years."

Continuing after IGY

Yet the radical changes in outlook that have come about during the International Geophysical Year will continue to change men's attitudes, so that the greatest gifts of science to peace are yet to come.

Within the world of science, peaceful co-operation continues. The Geophysical Year officially ends with 1958. But its sponsor, the International Council of Scientific Unions, met in Washington in October and created several committees that will plan the extension of present researches:

The Committee on Space Research will include the nations that have launched satellites and the individual scientific unions that are involved, such as that in astronomy. It will co-ordinate world-wide space research in the future and will co-operate with the United Nations in the regulation and control of scientific activities in space. For instance, it will establish a code for landings on the moon. It hopes to provide space in future satellites for the experiments of scientists of countries that do no launching.

The Special Committee on Oceanic Research will conduct an intensive study of the Indian Ocean to probe, among other things, the energy relationships between wind and waves and the energy balance of the ocean itself.

Finally, a Special Committee on Antarctic Research will continue to guide and co-ordinate the joint studies of many nations on that continent.

Open to all men

The International Council of Scientific Unions also issued a clear, ringing statement against political discrimination in scientific matters. It affirmed "the right of the scientists of any country or territory to adhere to or to associate with international scientific activity without regard to race, religion, or political philosophy." The International Council will recognize any qualified scientific group irrespective of the status of the government that controls it. Further, the Council will hold its meetings only in countries that permit attendance by scientists from any nation and allow free and prompt dissemination of information concerning the meetings.

Scientific knowledge and its use are, by their very nature, open to all mankind. Now the organized scientists stress the fact that research — the pursuit of scientific knowledge — is essentially international, too, and that all nations will fare best under mutual friendship and co-operation. Geophysics sets an excellent example for geopolitics.

By Isaac Asimov

Smaller than the atom

In recent years, scientists have discovered a bewildering variety of sub-atomic particles. Where do they fit into the structure of the atom? When we know the answer, a new age of science may begin. Part 2

The story to date

The atom was once thought to be the smallest piece of matter. Then three smaller particles — the electron, the neutron, and the proton — were discovered within the atom. In 1932, the picture of the atom included: neutrons and protons squeezed into an atomic nucleus in the center of the atom; and electrons filling the outer portions. But the picture was far from complete. Every once in a while, scientists found, certain atoms expelled particles with great energy. In the process, the atomic nucleus lost some of its mass. Actually, the mass was converted into energy. So the energy gain had to equal exactly the loss in mass. But in some cases the gain in energy turned out to be less than *the loss in mass. So, the scientists reasoned, another particle must be carrying off the missing energy. They finally detected the particle and called it the neutrino.*

■ Mass can be converted into energy, yes: but the reverse is also true. Energy can be converted into mass!

But there is a difficulty here. The destruction of a small quantity of mass will result in the creation of a large quantity of energy. (The atomic bomb is the most dramatic proof of that.) This means that to reverse the process we must use up a comparatively large quantity of energy to create even so small a bit of mass as a sub-atomic particle.

Fortunately, a great deal of energy is concentrated in the *cosmic rays* that bombard the earth from outer space. Cosmic rays consist mostly of speeding protons. These invade our atmosphere and smash into atoms in the air with terrific energy. Some of this energy reappears in the form of unusual particles. These are formed at the moment an atomic nucleus shatters under the impact of a speeding cosmic particle.

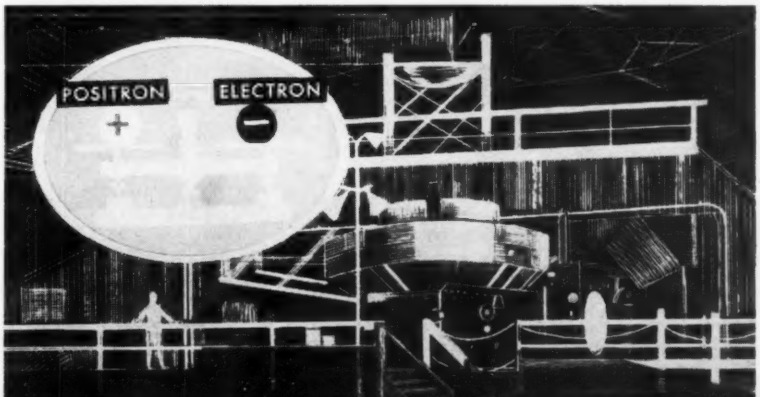
In 1932, cosmic rays striking a lead plate formed a particle that behaved exactly like an electron in many ways. It had exactly the mass and the size of charge of an electron. But the nature of the electric charge was positive, whereas the electron's charge was negative. It was a "positive electron." So it was therefore named a *positron*.

As it happened, the physicist Paul Dirac had predicted, four years previously, that such a "positive electron" must exist. In fact, he had stated that other particles might also have opposites.

For many years, physicists wondered if there might not be some particle that was the opposite of the proton — just as massive, but negatively charged.

Forming a particle the size of a proton, however, is much more difficult than forming one the size of an electron. A proton is 1,836 times as massive as an electron. It would therefore use up 1,836 times as much energy in being formed.

By the 1950's, though, atom-smashers were growing powerful



WHEN AN ATOM is smashed under certain conditions, a particle with the mass of an electron, but with a plus charge, is released. This particle is called a positron.

enough to supply the necessary energy. In 1955, twenty-three years after the discovery of the electron's opposite, the proton's opposite was detected. This "negative proton" was given the name *anti-proton*. Matching that, the positron is sometimes called the *anti-electron*.

There is reason to think that even uncharged particles have their opposites, or *anti-particles*. For instance, it is accepted now that an *anti-neutron* exists.

Of course, this may seem odd to you. An anti-proton is just like a proton, but is opposite in charge. Similarly, an anti-electron (positron) is just like an electron, but is opposite in charge. But since a neutron has no charge, in what way can an anti-neutron be different?

The answer seems to be this: The neutron, which is always spinning, behaves like a tiny magnet, as do other sub-atomic particles. It has a north pole in one direction and a south pole in the opposite direction. An anti-neutron, spinning in the same manner and direction, has its poles reversed.

Likewise, there is both a neutrino and an *anti-neutrino*. The type of nuclear reactions that go on in the sun or in hydrogen bombs produce neutrinos. The nuclear reactions involved in ordinary radioactivity or in atomic bombs produce anti-neutrinos.

In our own neighborhood of the universe, ordinary particles (electrons, protons, and neutrons) are very common. But the anti-particles are extremely rare.

In fact, the two kinds of particles can't exist very long together. When a positron is formed, its rapid motion is bound to bring it into collision with an electron within a billionth of a second or so. When that happens, the two particles seem to annihilate each other. Both cease to exist. In their place are gamma rays with an amount of energy just equal to the amount of mass that has disappeared.

In the same way, when an anti-proton meets a proton, they annihilate one another. In this case, though, much more energy is formed. The reason: the particles are much more massive.

In other words, anti-particles, formed out of energy, quickly change back into energy.

Some people have speculated that there may be places in the universe where it is the anti-particles that are common. There, our ordinary particles would be only rarely formed and would be quickly destroyed.

In such a reversed area, atoms would be made up of anti-protons and anti-neutrons in the nuclei, with anti-electrons (positrons) filling the outer reaches. Such atoms would form *anti-matter*.

Anti-matter would have all the properties of ordinary matter. From a distance, it would be impossible to tell whether a planet, for instance, was composed of matter or anti-matter. However, if a piece of anti-matter touched a piece of ordinary matter, the two would destroy each other and produce a grand explosion of gamma rays.

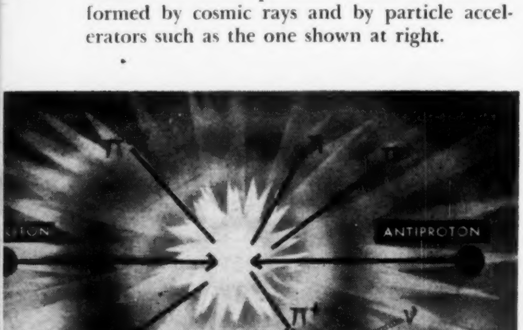
We now have a total of eight particles — the electron, the proton, the neutron, the neutrino, and their four anti-particles. A number of other particles are formed by the bombardment of atoms by cosmic rays. All of these particles are very short-lived.

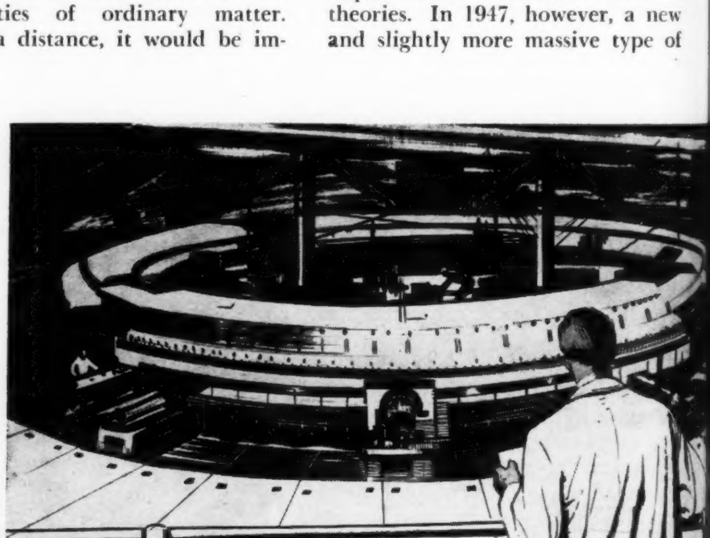
Beginning in 1935, for instance, particles were discovered that were more massive than electrons but less massive than protons. They were of intermediate mass. Since the Greek word for "intermediate" is *meso*, they were first called *mesotrons*. This was quickly shortened to *mesons*.

Now, mesons had also been predicted by theory. A Japanese physicist, H. Yukawa, had suggested that the forces holding an atomic nucleus together originated through the interchanging of electric charges by the protons and neutrons within a nucleus. These charges were interchanged in the form of charged particles of intermediate mass.

The mesons discovered in 1935 did not, unfortunately, quite fit the requirements of Professor Yukawa's theories. In 1947, however, a new and slightly more massive type of

COLLISION of a positively charged proton and its negatively charged twin, an anti-proton, results in the annihilation of both and the release of energy and many particles (*below*). Other sub-atomic particles called mesons are formed by cosmic rays and by particle accelerators such as the one shown at right.





Illustrations for this article are from the new filmstrip, "What's in the Atom?" courtesy of Film Strip-of-the-Month Clubs, Inc., New York, N. Y.

meson was discovered among the fragments of cosmic-ray bombardments.

The lighter mesons had masses equal to 207 electrons. They were named *mu-mesons,* or *muons* for short. The more massive ones had masses equal to 273 electrons. They were named *pi-mesons,* or *pions.* (*Mu* and *pi* are letters of the Greek alphabet.) It is the pions that seem to fit Professor Yukawa's theories.

Then mesons with even greater masses were discovered. These had masses equal to about 966 electrons. They were thus fully half as massive as protons or neutrons.

So many mesons of so many types were soon being discovered, in fact, that there was serious danger of confusion in the naming of them. In 1953, it was decided to lump muons and pions together under the name of *L-mesons.* The newer, more massive mesons were called *K-mesons.* (Meanwhile, particles with masses equal to or smaller than an electron's had been given the group name of *leptons,* from the Greek word meaning "small" or "weak.")

To complete the picture, an entirely new variety of particles was discovered in 1953. These were the most massive single particles of all — even more massive than protons and neutrons. Some were as much as 40 per cent more massive. These extra-massive particles were called *hyperons,* the Greek prefix *hyper* meaning "over" or "above." Different varieties of hyperons have been named with various Greek letters.

All these mesons and hyperons exist in charged and uncharged varieties. (All charged particles so far discovered, by the way, carry exactly the same amount of either positive or negative charge. The charge is always either +1 or —1.)

A summary of all the particles mentioned in this article is given in the accompanying table. As you can see, the model of the atom has grown complex.

The neat model first formed in 1932 had only neutrons, protons, and electrons in it. This model is still useful in explaining many chemical and physical phenomena. But for those physicists interested in the internal structure of the atomic nucleus, the 1932 model has joined the billiard-ball model of 1890. It will no longer do.

Class of Particle	Name of Particle	Mass (Electron=1)	Charge
LEPTON	Neutrino	0	0
	Anti-neutrino	0	0
	Electron	1	—1
	Anti-electron (positron)	1	+1
L-MESON	Negative muon	207	—1
	Positive muon	207	+1
	Neutral pion	265	0
	Negative pion	273	—1
	Positive pion	273	+1
K-MESON	Neutral K_1	966	0
	Neutral K_2	966	0
	Negative K	966	—1
	Positive K	966	+1
NUCLEON	Proton	1836	+1
	Anti-proton	1836	—1
	Neutron	1837	0
	Anti-neutron	1837	0
HYPERON	Lambda	2182	0
	Neutral sigma	2325	0
	Positive sigma	2327	+1
	Negative sigma	2343	—1
	Xi	2585	—1

LIST OF SUB-ATOMIC PARTICLES

In fact, these are exciting times because there is now no model of the atom that will do. Physicists know of two dozen different particles of widely varying types. And perhaps more will be discovered soon.

Where are all these to be fitted in? Where do the anti-particles belong? Into what niches can all the bewildering variety of mesons and hyperons be placed?

There must be some answer. Once it is known, atomic structure will be understood in a clearer and more fundamental way. And when that happens, what will the future bring?

After all, the change from the 1890 model of the atom to the 1932 model meant a scientific advance that brought us to the verge of practical nuclear power. A new model may mean a new advance, perhaps a faster and further one that will end ——

Where?

ANTS ANTS ANTS

Do you have a leaning toward entomology? If so, have a look at the ants in your own backyard. For ants, reports the author, are among the most amazing and fascinating of insects

By Roy A. Gallant

■ For years, ants have excited the curiosity of both the naturalist and the psychologist. And ants make splendid subjects of study for the amateur naturalist. For one thing, the behavior and life cycle of ants can be observed without a microscope. For another, ants are plentiful. They live in deserts, in tropical and temperate zones — in fact, everywhere between the borders of constant frost. To date, entomologists know of more than 3,500 species of ants. Because they are the most numerous of all land creatures, they are readily available for the professional and home laboratory. You need go no farther than your backyard. And Dr. Theodore C. Schneirla of New York's American Museum of Natural History has described the ant as "one of the most successful of nature's inventions." The first ants, he says, appeared at least 65 million years ago; and they reached their "present state of perfection no less than 50 million years ago." By comparison, man is still an infant.

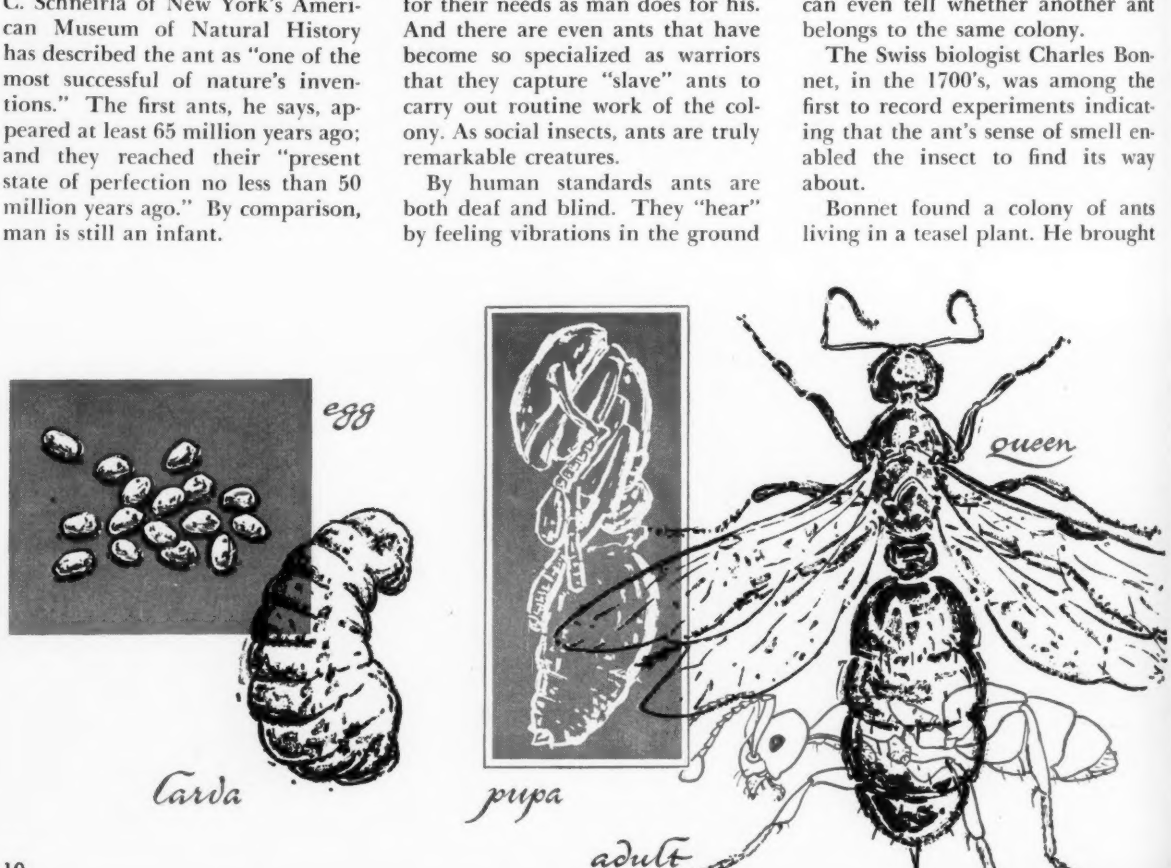
Because there are so many species of ants, it's no surprise to find a wide variety of habits among them. To cite just a few examples:

While most species make their homes beneath the ground and hunt for food by wandering over the surface, others prefer to live in city hotels and apartment houses. Some spend their entire lives beneath the ground, opening the entrance to their nests only at mating times. Still other ants live in trees, inside plants, or among plant leaves. Some eat only other animals and go on mass raiding parties in search of food; others eat only plants. Among the plant eaters are those who farm crops as efficiently for their needs as man does for his. And there are even ants that have become so specialized as warriors that they capture "slave" ants to carry out routine work of the colony. As social insects, ants are truly remarkable creatures.

By human standards ants are both deaf and blind. They "hear" by feeling vibrations in the ground with their bodies. Sight in most species is limited to distinguishing light from dark. Since most ants spend much of their time underground, it is understandable that they need some strong sense organ that does not depend on light, as sight does. In ants the primary sense is smell. It approximates our sense of taste and is located in their antennas, which act as chemical detection rods. Using its antennas, an ant can "smell" an air odor. It also "smells" an object by passing one of its antennas over the object. You see the weaving action of their antennas whenever ants examine a piece of food. In fact, so delicate is this sense of smell-taste that an ant can even tell whether another ant belongs to the same colony.

The Swiss biologist Charles Bonnet, in the 1700's, was among the first to record experiments indicating that the ant's sense of smell enabled the insect to find its way about.

Bonnet found a colony of ants living in a teasel plant. He brought



the plant indoors and placed it on one end of a table; then he put some sugar at the other end. One ant, then two, then others trooped to the sugar and returned to their nests in the plant. In a short time, a steady, two-way file of ants extended across the table. Bonnet next dragged his finger firmly across the ant path. The ants coming from both directions stopped at the finger mark. They waved and tapped their antennas in confusion. Finally, the front ants on each side of the finger mark ventured toward each other, recognized the friendly scent, and resumed the chain. Bonnet concluded that a "trail" of some sort guided the ants. But he didn't prove it was a chemical trail that the ants could smell.

In the late 1800's, the Swiss entomologist Auguste Forel concluded that the ant's sense of smell was located in its antennas. On examining an ant's antenna, he found organs of different shapes, all supplied with nerves. These organs, he said, gave the ant its sense of smell-taste. Furthermore, he concluded that ants could detect the *shape* of an odor, but this last finding was only a suggestion and has not been borne out.

Returning to the Bonnet experiment, other biologists tried creating an odorless gap across an ant trail. To do this they used a piece of cotton rather than their fingers. When the gap was only an inch or so wide, the ants — unlike Bonnet's — continued across without pause. It would appear, then, that a finger smear leaves some odor that confuses the ants, but a narrow, odorless cotton "smear" does not throw the ant off its trail.

An ant leaves a trail by issuing drops of liquid from its abdomen. When an ant has found a rich food supply, it returns to the nest and transmits its excitement to other ants. They scurry out and, when returning to the nest with food, further strengthen the scent trail. The greater the food supply, the greater the excitement and the stronger the scent trail. This ability of ants to recognize odors with their antennas is called "chemotactic perception."

Ant communities

A question that has long puzzled biologists is this: since the ant is such a primitive creature, how can we account for its highly ordered social behavior?

The caste system among ants is an interesting one, although it is not entirely understood by entomologists. Essentially, there are three divisions:

1. The *queen* ant, known as the "functional female," lays up to 25,000 eggs, which hatch into a new colony. Queen ants usually have wings until their first mating, after which they discard the wings.

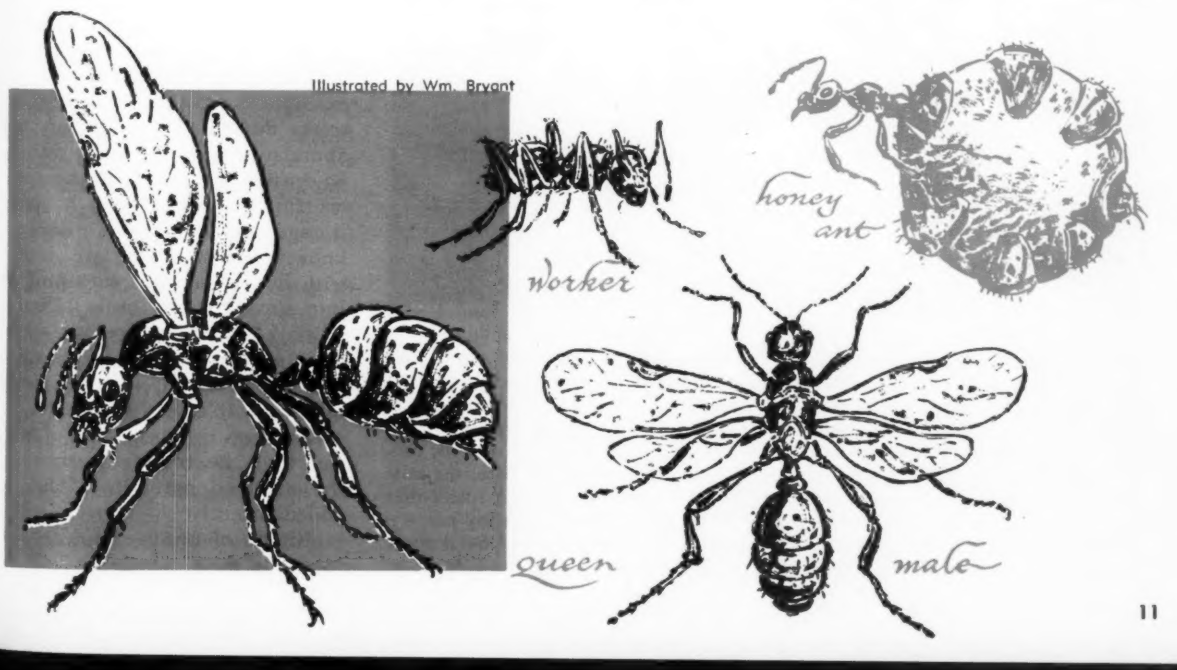
2. The *workers*, although female, do not produce young of their own. Born without wings, they care for the eggs laid by the queen and supply the colony with food. A queen ant may live to an age of 15 years, whereas a worker's life may be as short as a month or as long as three to six years.

3. The *male* ants are usually winged.

Exactly what decides whether an egg will develop into a male, a worker, or a queen still puzzles entomologists. Some researchers suspect that, as with bees, the kind of food the workers give to the young determines whether a fertilized egg will develop into a queen or worker. In most cases, unfertilized eggs do not die, as might be expected, but develop into males.

Ants sharing the same nests carry on in a way that is also a puzzle. The late William M. Wheeler, a Harvard entomologist, termed this behavior "trophallaxis" — from the Greek words *trophe*, meaning food, and *allaxis*, meaning exchange. The strong attraction nest-sharing ants show for one another is seen as they nuzzle each other, rub antennas, and exchange regurgitated food and glandular secretions. Apparently, most ants will die if they are deprived of this biosocial relationship.

Although one ant is friendly with other ants of the same colony, ants of a different colony enrage



him. According to zoologist John Paul Scott: "There is no opportunity for an ant to become socialized to another species. Death follows any contact with other colonies... Occasionally one comes across examples of inter-colony ant fights on a large scale. The ants may go on fighting for a couple of days, leaving the ground littered with corpses."

To find out more about ant conflicts, biologists conducted the following experiment: First they removed larvae of different species from their nests and raised the ants in the laboratory. These ants did not show any antagonism toward one another, which seemed to prove that hatred between species is not hereditary. The question, then, was how do ants identify "strangers"? In another experiment, an ant of one species was bathed in an alcohol solution. Next it was dipped in the juices of an enemy species and placed among the enemy. The ant was not harmed, but on being returned to its own species it was killed. It would seem that each ant associates well-being and friendliness with the particular chemical taste and odor of its own group. All other group odors signify "hostility."

This finding explains the workings of the "slave system" among certain ants. The Amazon ants, for example, make raids on colonies of smaller ants and steal pupae for food. The pupae that hatch before being eaten become slaves of the Amazon captors and are accepted in the group. The Amazon ants could not survive without their slaves. Their long, curved jaws have become so specialized for fighting that they can no longer feed themselves or their young. An Amazon ant may have six or seven slaves which accompany her on hunting raids during which many slaves are slain.

Food gathering

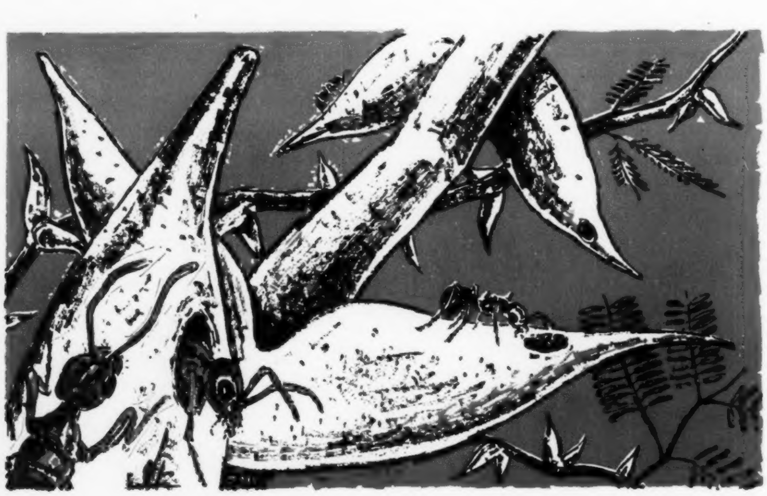
Many groups of ants long ago gave up flesh-eating, although they will eat a dead insect. The harvester ants form one such group. Today their diet consists chiefly of seeds, which they gather and store as squirrels store acorns.

The leafcutter ants, sometimes called parasol ants, grow their own crops. They feed exclusively on fungus that they cultivate in underground gardens. To raise their crops, some species of these ants collect pieces of leaves, which they chew and feed to the fungus. The division of labor in these colonies is clear-cut. The large, powerful workers collect the leaves and carry them into the colonies where smaller workers take over the chewing and feeding task. In a single night, a raid of the leaf gatherers can strip a tree of all its foliage!

Possibly the most remarkable food gatherers are the ants that live on honeydew — the excreta of certain insects. The honey ants, for example, know that honeydew is scarce during the dry season, but abundant during the moist seasons. So during the wet season the workers store excess honeydew in living storage bins. Certain workers, known as "repletes," are stuffed with honeydew until they puff up into small balloon tanks. Unable to walk about, the repletes spend their entire storage lives hanging from the nest roof, waiting to serve the colony in case of need.

Studying the behavior of ants can be a fascinating pastime for the amateur naturalist. And, as added incentive — there is still a multitude of unsolved riddles surrounding these creatures.

Army ants of the tropics are wanderers. By the thousands, they troop through the jungle, eating the flesh of nearly any animal they can overpower. At night they bivouac by linking themselves together and hanging in tree hollows or from overhanging logs. Within the living mass the queen, her eggs, larvae, and pupae are held and protected by the bodies of the workers. At daylight part of the swarm breaks away, ventilating the queen's area, and troops off for food, returning in the evening. When new adult ants emerge from the pupa stage, the entire swarm moves on. The march continues, with a new camp selected each night, until the queen is ready to lay another batch of eggs. In one species of army ant (*Eciton hamatum*) the ants wander for about 17 days, then spend 19 or 20 days in fixed bivouac.



Ants of the genus *Pseudomyrma* live in partnership with the bull-horn acacia tree. The ants protect the tree from insect enemies, and the tree provides the ants with food and shelter. After boring a hole in each thorn of the tree, the ants crawl inside, where they raise families and store food. The tree itself provides the ants with food in the form of honey-like liquid and a fruitlike body rich in oils, proteins and carbohydrates. Because the fruits do not all mature at once, the ants keep watch, constantly inspecting the fruits. As a result, any foreign insect that touches the tree is detected and attacked. If an animal (even a man) jars the tree, thousands of ants emerge from the thorns to defend the tree by severely stinging the invader. This partnership in living is an example of symbiosis.

By Rose Wyler

The legacy of the Alchemist

One of the dreams of Bernard Trevison (1409-90) was to transform lead into gold. But he hoped to achieve much more than this. As a dedicated alchemist, the Italian monk was searching for the philosopher's stone — a substance that would give wisdom to the foolish and fertility to the childless, cure all disease, and even resurrect the dead. Since the wonderful stone would improve every aspect of nature, it would transform the baser metals such as lead, iron, and copper into the most noble and perfect metal of all — gold.

At least, so it was said in the writings of the alchemists, the forerunners of the modern chemists. Brother Bernard could believe them. For, like everyone else of his time, he had no knowledge of chemical composition or of the laws of chemical change. It did not matter that their recipes for making the stone did not work out. Every sincere alchemist thought that only the most worthy could achieve the synthesis.

Brother Bernard, also known as the Good Trevison, had faith in his worthiness. His method of work, however, was trial and error — and mostly error. Reasoning that heat and distillation purified substances and made the less perfect more perfect, he applied these processes to an amazing variety of substances.

The monk regarded anything associated with life as a source of materials for the stone. In the works of the great alchemists, the philosopher's stone was described as "the stone that is not a stone." Sometimes it was referred to as the egg, and sometimes as the elixir of life.

For twelve years, Trevison worked on distillation. He tried to make the stone from sea water, since many kinds of life were born in the sea. After he evaporated the water to isolate its salt, he re-crystallized the salt hundreds of times. But this did not transform it. So he finally abandoned the project.

At the age of 40, Trevison decided to try to obtain the philosopher's stone from hens' eggs. Working with another monk, he spent eight years boiling two thousand eggs, removing their shells, heating the shells until they became powdery, purifying the yolks and whites in manure, then distilling the resulting mixture thirty times. The yield was two mysterious liquids — one red and one white.

Were these the ingredients of the stone? Eagerly, Trevison tried the precious fluids on one metal, then another, but none of them turned to gold. Once again he had failed.

Still the alchemist did not give up. He traveled from country to country, seeking help and advice from other adepts. He clung to his belief in the philosopher's stone to the end of his long and full life.

The story of the Good Trevison is by no means unique. For 1,500 years or more, alchemy attracted thousands of followers. Many of them were the most gifted and intelligent men of the civilized world.

The long history of this pseudo science can be traced back to the days when Greek culture flourished in Alexandria, Egypt. Then, as now, the making of imitation jewelry was a thriving business. A papyrus, probably written in the third century A.D. as a manual for jewelry manufacturers, gives several clearly stated recipes for making alloys that look like gold. Manuscripts of a somewhat later date, however, present the recipes in mysterious jargon and refer to alloy-making as the actual changing of base metals into gold. Evidently, the makers of fake gold were so successful in deceiving the public that they began to deceive themselves.

The men who claimed to have made gold found it convenient to use several ideas of the ancient Greek philosophers. These sages had said gold was perfection itself and silver near-perfection, since neither metal could be destroyed by fire. But lead, iron, copper, and tin were considered base and imperfect. The noble and base metals were related, the alchemists reasoned, since all substances were made of only one kind of matter —

Illustrated by Paul Gra

prima materia. This acquired different forms as certain qualities were added or removed from it. Therefore, transmutation — the changing of base metals into gold — could be achieved by reducing a substance to *prima materia* and then adding the right proportions of the desired qualities to it.

Alchemy in the Middle East

From Egypt, these ideas spread to the Middle East. There, the Arabs embellished them with the sulfur-mercury theory of metals. This assumed that sulfur had the quality of combustibility, while mercury embodied fusibility or liquidity. The interaction of these qualities in the bowels of the earth, according to the theory, produced base or noble metals, depending on the purity. Superfine sulfur and mercury would yield a stone that was much purer than ordinary gold. Consequently, only a few grains of this substance would provide a seed with the power to transform large amounts of base metal into gold of normal purity.

The baseness of metals came to be regarded as a disease, which could be treated by the medicine of the stone. From this, it seems, came the idea that the stone could also serve as a medicine for man and act as an elixir of life. Further confusion was caused by bringing in the egg, the symbol of creation. This was associated with the word "seed" in texts on alchemy written in Arabic. In time, it came to stand for the stone itself.

In the twelfth century (during one of their invasions of Spain), the Moors introduced alchemy to Europe. Scholars of the Middle Ages translated the Arabic works on the subject and soon were producing treatises of their own.

As alchemy swept across Europe, new techniques were developed. Equipment became more and more elaborate. It soon included a variety of flasks, beakers, retorts, crucibles, mortars and pestles, filters and strainers, sand and water baths, complicated distilling apparatus, and a crude type of balance.

Several acids, including sulfuric, nitric, and hydrochloric acid, were discovered and used as reagents. A number of salts were also discovered. Of particular interest was the new substance alcohol, prepared by the distillation of wines and beers. This was called "the water of life" and ranked second only to the elixir of life. Monks and friars took up the study of its properties, hoping their work would lead to the stone.

While interest in alchemy was at its peak, numerous charlatans prospered. They used a convincing trick to sell gold-making recipes to gullible men of wealth. Before performing the trick, the swindler always slipped some genuine gold into a piece of charcoal or into a hollow stirring rod that was blackened and sealed with wax. At the demonstration, he set up a furnace, filled a crucible with mercury, and poured in the "stone" — probably a little chalk or red lead. While the furnace was warming up, the prepared charcoal was set above the crucible, or the stirring rod was brought into use. Heat from the furnace soon released the precious metal, which mixed with the mercury. As the heat grew more intense, the mercury vaporized, leaving gold in the crucible.

Swindles occurred frequently. In addition, there was a real fear that gold would become so abundant that it would be worthless. For both these reasons, many countries passed laws against alchemy. In 1317, Pope John XXII issued a warning against it.

Yet, devoted adepts continued their labors. If the stone were found, they argued, it would speed up nature's own processes. To the alchemists, there was ample evidence that nature was constantly striving to make the less perfect more perfect. When water evaporated, there usually was a salt residue. Did this not prove that water had changed to earth? When a piece of iron was plunged into a solution of blue vitriol (copper sulfate), copper appeared. Who would doubt that iron had been transmuted?

Despite the falseness of these arguments, there was no way to disprove them. Even such an eminent scientist as Isaac Newton was influenced by them and dabbled in attempts at gold-making, after buying and carefully studying the works of many master alchemists.

Faith in the philosopher's stone was so great that this belief was not abandoned until nearly every known substance had been tested. Actually, alchemy was never overthrown — it developed into chemistry. In the slow process of learning how to make new substances from old, many useful compounds were discovered. Doctors began to use some of them for curing specific diseases. Craftsmen found out how to use them to improve their wares. Gradually those who worked with chemicals learned how to conduct controlled experiments, to draw generalizations based on observations, and to check their theories by practice. To a large extent, it was knowledge gained through practical uses of substances that transformed the psuedo science of alchemy into the true science of chemistry.

Alchemist into chemist

Chemistry has made many of the dreams of the alchemists come true. Gold can now be made by smashing atoms of other metals, though at such great expenditures of energy that it does not pay commercially. Many chemicals have been produced to fight disease and prolong life. Numerous substances that do not appear in nature and that surpass natural products have been prepared. And more useful substances are constantly being sought. In a sense, the aims of the alchemist were the same as those of the chemist — to improve on nature and to prepare substances that promote human welfare.

If Bernard Trevison could walk into a modern chemical laboratory and watch chemists at work, he would soon feel at home. His eyes would light up as he recognized many of the pieces of apparatus and reagents that he himself had worked with. He would see them used in many of the processes that he and other alchemists had developed. He could say with pride, "This is our legacy to you, the chemists. This equipment helped you discover something that you call the experimental method. Call it what you will. Beyond doubt, it is the object of the alchemist's quest — the philosopher's stone."

Science in the news

Manned satellite may be launched in 1960

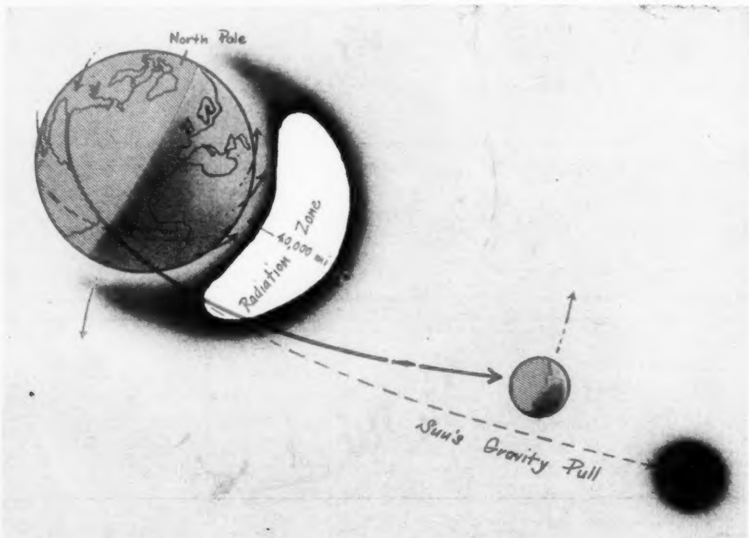
The U.S. hopes to launch a manned satellite as early as 1960. According to present plans, the satellite will be a one-ton sealed capsule. It will be fired into an earth-circling orbit by an Atlas intercontinental ballistic missile. (The Air Force's Atlas recently proved itself a potentially reliable vehicle by rocketing a distance of 6,300 miles over the ocean from Cape Canaveral, Florida.)

If all goes well, the satellite will circle the earth at about 18,000 miles an hour at an altitude of 110 to 155 miles. This is far below the level of the earth-circling belt of deadly radiation discovered by the Explorer satellites. After twenty-eight hours or so in orbit, the satellite and its human passenger will descend to the earth.

The big problem, of course, is to give the man a reasonably good chance of living through his experience. Before he makes his trip, satellites carrying dummies and animals will be launched. In the meantime, scientists will be working on a number of safety features. Among them:

- To prevent the man from being bounced around, he will be firmly strapped into place at the base of the cone-shaped capsule. During the launching he will be lying on his back. A special suit will help him withstand the high gravity forces during launching and during re-entry into the earth's lower and thicker atmosphere. Noise and vibration absorbers will be used.
- In case of trouble during launching or shortly thereafter, an automatic ejection system will go into operation. The capsule will be perched on top of the Atlas and its highly explosive propellant. If something goes wrong, the capsule will be blasted upward at least 2,500 feet and to the side. This should be a safe distance in the event of an explosion. A parachute will float the capsule to earth.
- Tiny jets mounted around the capsule will counteract any spinning or tumbling of the capsule after it is in orbit. This motion could cause blood and other body fluids of the occupant to rush to his extremities, possibly killing him. The jets will also be used in the descent to guide the satellite into the denser atmosphere in such a way as to reduce the heat from air friction. Rockets will be fired to slow the capsule's speed as it re-enters the lower atmosphere. Finally, parachutes will slow its fall to the earth.

Drawing by Wes McKeown



Army moon-shot plan is shown in diagram. Unlike Air Force shots, which aimed at putting a satellite into orbit around the moon, the Army rocket was aimed for a direct hit (*solid line*) but in the expectation that the rocket would miss the moon and that the sun's gravitational pull would cause it to orbit the sun. Shaded area indicates one zone of intense radiation; another is present on opposite side.

Army's Pioneer III probe fails to reach moon

Too flat a trajectory and an early burnout in the first-stage rocket engine spelled failure for the Army's first moon probe, Pioneer III. The launching, which took place at 12:45 A.M. on December 6, initially appeared successful. Then Army and NASA scientists found that the modified Jupiter IRBM first stage had burned out too soon. As a result, Pioneer III failed—by about 1,000 mph—to acheive the 25,000 mph velocity required to escape the earth's gravitational pull. As this issue of *SW* went to press, Pioneer III's peak altitude was being estimated at 65,000 miles.

All animals may have a juvenile hormone

Scientists recently found a new hormone secreted by insects. Called the juvenile hormone, it can prevent insects from maturing into their adult forms. Now zoologists at Cornell University have also discovered the hormone in cows and jellyfish.

In the case of a moth, the hormone is secreted during the insect's larval, or caterpillar, stage. When the larva reaches maturity, no more hormone is secreted. The insect then goes through metamorphosis, gradually changing into an adult. But if the juvenile hormone is injected into the full-grown caterpillar, metamorphosis is postponed. The caterpillar grows to giant size. It then changes into a giant pupa and finally into a giant moth.

Zoologists at Cornell University obtained a chemical from a cow's adrenal glands. When the chemical was injected into immature insects, it delayed their metamorphosis just as the insect's own hormone can.

Cornell investigators also found a similar chemical in jellyfish. The jellyfish is one of the most primitive animals. So scientists think the hormone may exist in most—if not all—animals, including man. But its function in higher animals isn't known.

Atomic clocks uphold theory of relativity

A highly sensitive electronic device called a maser has given near-conclusive proof of Einstein's special theory of relativity. According to this theory, the velocity of light (186,272 miles per second) remains constant (unchanged) regardless of the motion of an observer. In other words, it doesn't matter whether a beam of light travels in the same or in an opposite direction from the earth's motion around the sun. Either way, the velocity of light is the same.

Physicists of Columbia University and of International Business Machines Corporation joined forces to test the theory in what was probably the most precise experiment in history. They used two masers as checks against each other. One was aimed in the direction of the earth's motion, the other was pointed in the opposite direction.

A maser is an atomic clock that counts time intervals with great precision. *Maser* means "microwave amplification by stimulated emission of radiation." When ammonia molecules are beamed at high speed into the tubular cavity of a maser, the ammonia molecules vibrate and give off radio waves. Now, radio waves and light waves are both electromagnetic waves. If the velocity of one is constant, so must be the other. And any change in the velocity of radio waves would be reflected in a change in their frequency.

When the frequencies of the radio waves from both masers were compared, there was only a slight difference: one cycle per second over a twelve-hour period. This difference was caused by the earth's magnetic field and other magnetic influences in the laboratory. If the earth's motion around the sun had been able to alter the velocity of these waves (or of light waves), the change would have shown up as a difference of 20 cycles per second, said the physicists.

Masers can now provide the speed and precision needed to test other consequences of the theory of relativity such as the relationship between time and velocity. Does time slow down as velocity increases? This question could be answered positively by putting a maser clock in a satellite revolving around the earth. The maser would give the correct time "outside of time." According to the principles of relativity, a clock aboard a satellite traveling at 18,000 mph should lag behind a similar clock on earth by about one twenty-thousandth of a second after a full day's time. A crew in a spaceship hurtling along at four-fifths the speed of light would find that a ten-year journey, as measured by a clock on earth, would register only six years on their space clock. Traveling at nine-tenths the speed of light, the trip would take only four years. But when the space travelers returned, they would find an earth that had grown ten years older.

Air pollution increasing, health survey reveals

The air we breathe is getting dirtier and dirtier. For, as cities and industries grow, so does the problem of air pollution. As you might expect, cities get the worst of it. Urban air pollution is about five times as intense as rural.

Delegates to the first National Conference on Air Pollution heard results of a nationwide survey made by the U.S. Public Health Service. Most alarming survey result: a definite link between city smog and disease, notably cancer of the lungs. Incidence of lung-cancer deaths in cities runs about twice as high as it does in rural areas. Although air pollution hasn't been *proved* a cancer cause, cancers have been produced in animals by using concentrates of city smokes.

Exhaust fumes from cars, trucks, and buses were blamed as a prime source of the smog that blankets large cities. In Seattle, one scientist-delegate said, "autos and trucks dump 100 tons of hydrocarbons, 20 to 80 tons of nitrogen dioxide, and 4 tons of sulfur dioxide into the city's air every day." The conference urged the auto industry to speed development of devices to curb the fumes.

Other survey results: Desert air is generally the cleanest in the nation. Mountain and forest air ranks second, and farm and Great Lakes shore air is third cleanest. Although the dry, desert air of Phoenix, Arizona, contains a higher volume of dirt than that of any other city, its particular kind of dust and grit is free of the chemicals that may produce cancer and other ailments. Los Angeles, often called the smog capital of the world, is the city with the highest concentration of these chemicals.

Air-filter samples shown ranged from a white filter lightly specked by the pure ocean air of the Florida Keys to one caked with jet-black grime from Cleveland, Ohio.

After hearing the survey's evidence, conference delegates called for a ten-year anti-pollution plan. This would use research facilities of both Government and industry. Air-pollution control now costs the Government about $4 billion a year. This amount will have to be expanded to keep pace with the growing problem.

News in brief

- Beginning in 1959, up to twenty-four space probes a year will be attempted by the U.S. Defense Department and the new National Aeronautics and Space Administration. The probes will include satellite launchings and shots at the moon and nearby planets. Vehicles will be launched from both the East and West Coasts. Each agency will launch progressively larger satellites. Both hope eventually to launch satellites weighing about five tons. Attempts will be made to put mice, monkeys, and finally men into orbit and to bring them back safely to earth. First satellite launching, Project Discoverer, is scheduled to be made sometime in January from Vandenberg Air Force Base near Santa Maria, California.

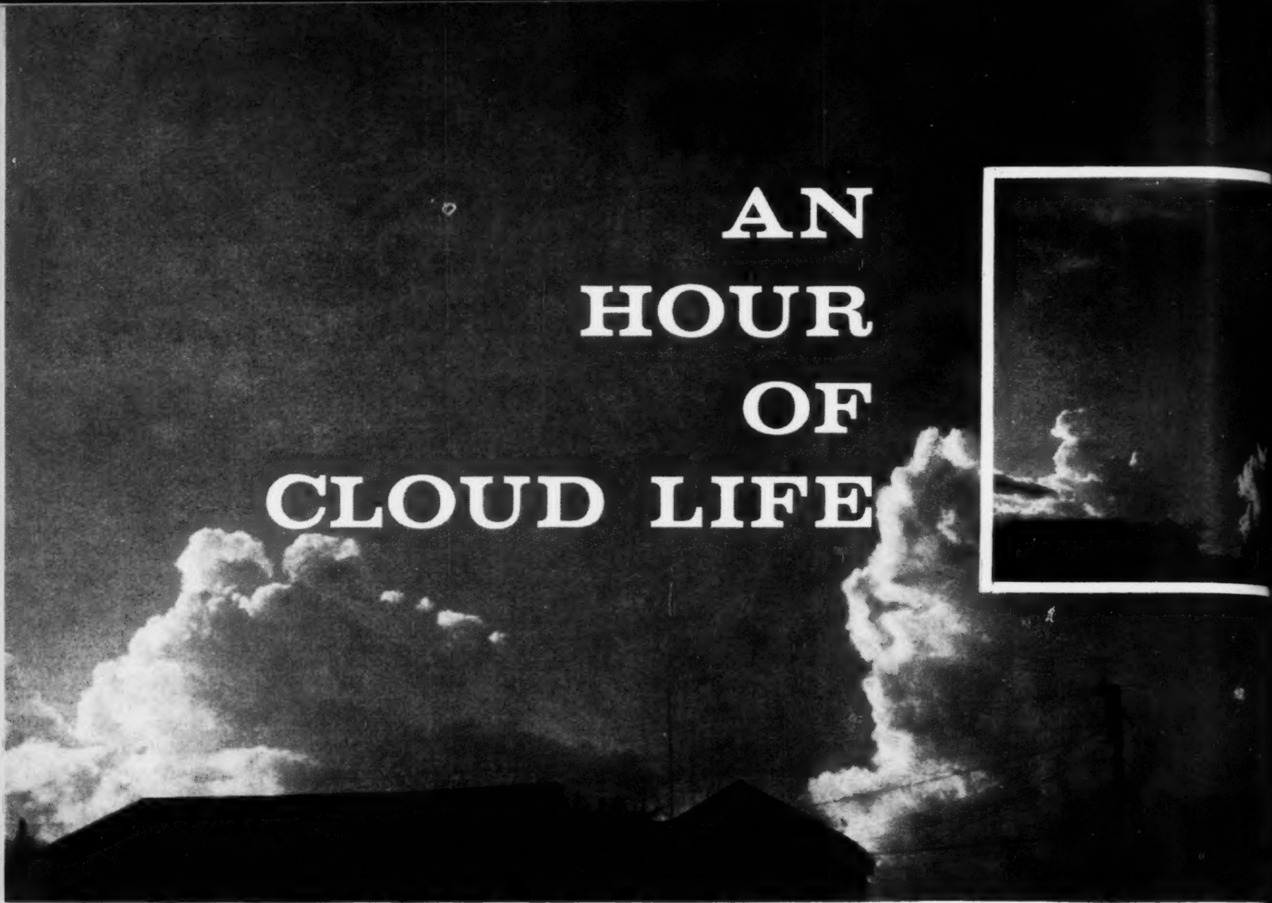
- A paper that can conduct heat has been developed. Scientists are testing it for use in indoor heating appliances and to melt ice and snow on driveways and airport runways. The entire surface of the paper gives off heat when copper foil strips along its edges are energized with electricity. The paper heats quickly and cools off fast. One of its ingredients, colloidal silica, contains microscopic particles that conduct electricity.

- Requests for land claims on the moon are pouring into the U.S. Department of the Interior. To handle the mountain of mail, the Department has drafted a form letter. It contains a polite, tongue-in-cheek refusal to grant claims for land on the moon or on other planets until there is some legal basis for regarding "such land as public land of the United States."

- Heavy waves are transformed into calm ones at the port of Dover, England. A pneumatic breakwater system at the harbor's entrance interrupts the rhythm of normal wave action and redistributes the waves so they are half their former size or smaller. Compressed air is piped from the shore along the sea bottom to the harbor's entrance. There, it is discharged in the form of large bubbles at controlled time intervals. Ships can pass freely through the bubble barrier.

- Bird and animal lovers are seriously concerned about the dangers to wildlife posed by some insecticides. The National Audubon Society has protested the use of these insecticides until their contents are more thoroughly analyzed. The protest grew out of reports of heavy animal losses, both wild and domestic, in areas where DDT, dieldrin, and heptachlor chemicals were used to combat insect pests.

AN HOUR OF CLOUD LIFE



Text and photos by George W. Reynolds

■ As you know, cloud watching is a fascinating pastime. But for the meteorologist — amateur or otherwise — clouds have another fascination, since the behavior of a cloud illustrates the dynamic character of the atmosphere.

Smooth-looking clouds extending over large areas tell us that there is not much horizontal variation in the condition of the air. Bumpy-looking clouds, like the ones in these photos, indicate that air characteristics are varying a great deal, horizontally as well as vertically.

The clouds on the horizon are the interesting ones in this series. These are cumulus-type clouds. They are moving from your left to right.

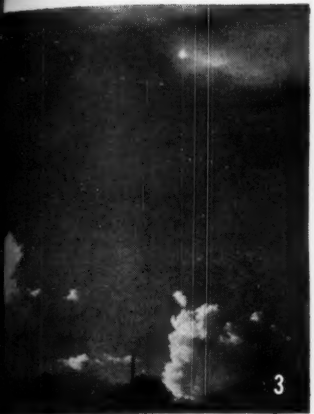
The cloud on the right has almost finished its growth at the beginning of the series. By the second picture (taken six minutes after the first), it has already begun to fade away. The condensed water droplets in the cloud are slowly evaporating into the atmosphere or dropping out at the bottom as rain.

The cloud on the left is fair-sized at the beginning of the series, but it continues to grow for another 25 or 30 minutes. Its dissipation begins at about the same place as the first cloud. This can be recognized by its position with respect to the telephone pole.

But cloud-left built up to a considerably higher level than the first. As a consequence, it reached a level at which atmospheric conditions were such as to force the cloud to spread horizontally. This has started by picture 6 and is very evident by picture 8. The top of this cloud is no doubt made up of ice crystals, which give a fleecy appearance.

At the beginning of the series, cloud-left is called a "swelling cumulus." (Actually, cloud names are not a cut and dried sort of thing. The same cloud may be called by different names when it is in the transition stage.)

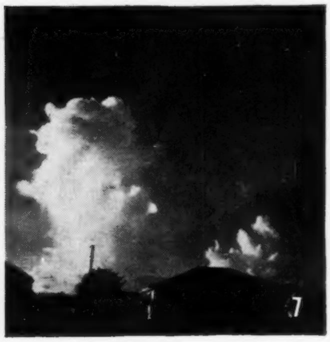
By picture 4, the cloud has become a full-fledged cumulus congestus. With the formation of the anvil cloud, the spreading out at the top, the cloud becomes a cumulo-nimbus. The transition from cumulus congestus to cumulo-nimbus is shown in pictures 6 to 8. As the cloud dries out from the bottom, only the upper part is left. This remaining cloud is called a "cirrus nothus."



How the photos were taken

These photos were taken at College Station, Texas, looking north at about three o'clock of an October afternoon. Mr. Reynolds used a Beauty-Flex camera, Plus-X film, a sun shield, and an orange filter.

He took a sequence of 21 photos at 3-minute intervals, using a telephone pole as a line of reference for following the growth and movement of the clouds.



Young scientists

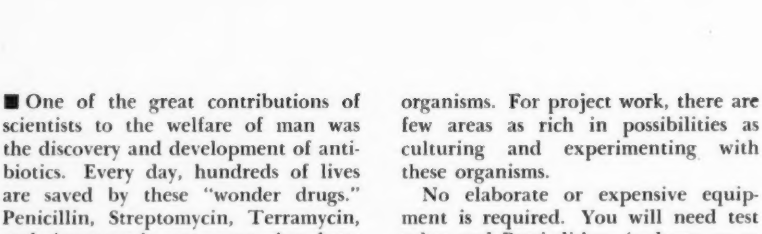
'FARMING' FOR ANTIBIOTICS

Here's how to develop your own strain of antibiotic-producing organisms

■ One of the great contributions of scientists to the welfare of man was the discovery and development of antibiotics. Every day, hundreds of lives are saved by these "wonder drugs." Penicillin, Streptomycin, Terramycin, and Aureomycin are some that have made medical history. As we know, antibiotics are produced by micro-organisms. For project work, there are few areas as rich in possibilities as culturing and experimenting with these organisms.

No elaborate or expensive equipment is required. You will need test tubes and Petri dishes (a dozen or so of each), a small box of unbleached cotton wadding, a glass alcohol lamp, a glass atomizer, and a quarter-pound of dehydrated nutrient agar (Difco). These materials can be obtained from school or purchased at a drugstore. A quarter-pound of nutrient agar will be enough for hundreds of experiments. You will also need a pressure cooker and a small funnel. These can usually be found in any well-equipped kitchen.

Now, one thing more. For transferring cultures, you will need a length of Nichrome wire. Replacement heating units, such as those used in repairing electric irons, are made of Nichrome wire. You can make several transferring loops from such a heating element purchased in the five-and-ten-cent store.

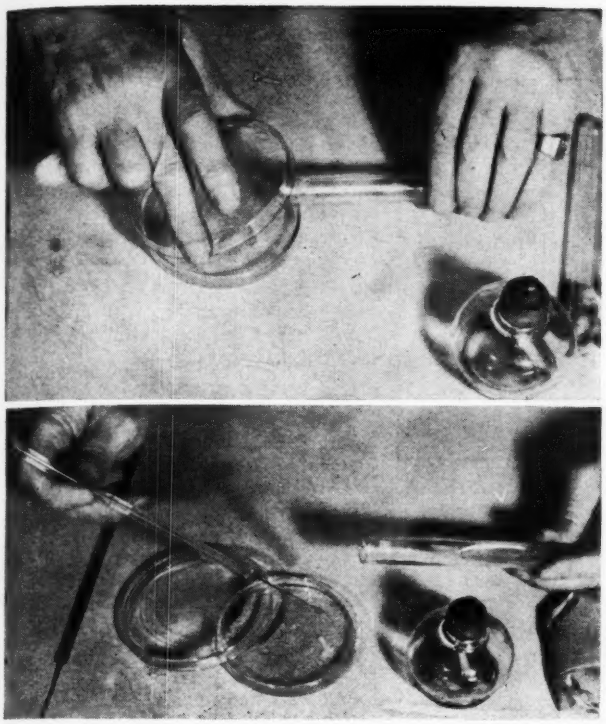


Basic materials for experimenting with antibiotic-producing micro-organisms.

Preparing the culture medium

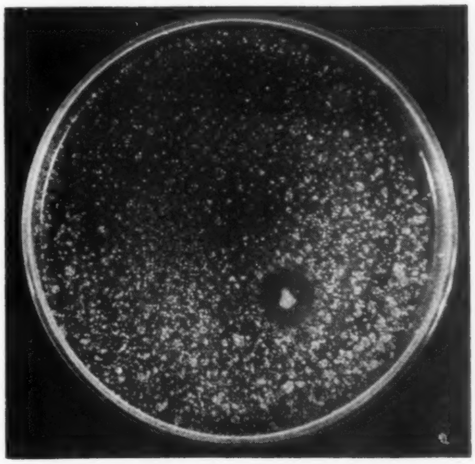
Your first step is to prepare a culture medium in which the micro-organisms will grow. You should have all the above materials gathered together before you start.

Dehydrated nutrient agar is the basic ingredient of the medium. It contains nutrients that will enable a wide variety of bacteria, molds, and



Two STEPS in developing micro-organisms: in top picture, melted agar is poured into Petri dish; at bottom, colony of organisms is transferred to agar slant tube by means of sterile Nichrome loop.

Photos by Elliott R. Weyer



ORGANISMS GROW all over dish except around colony of antibiotic producers (dark, doughnut-like area).

yeasts to grow. Add the nutrient agar to water in the proportions stated on the label. For most preparations, 4 grams of nutrient powder added to 200 cubic centimeters of water will yield a convenient starting amount.

Heat the solution to just under the boiling point in a kitchen saucepan. Stir constantly. Now pour the culture medium into your test tubes. Use a funnel to keep the medium from wetting the lips and sides of the test tubes. Fill half of the test tubes to a depth of one inch and the other half to a two-inch depth. As each test tube is filled, stopper it with a wad of unbleached absorbent cotton (which is less absorbent than the surgical variety). Stand the test tubes vertically in a tin can.

Sterilization

It would be well at this time to fill three or four test tubes half full of water. These will be sterilized with those containing the medium and will be used in experiments requiring sterile water.

You are now ready to sterilize the medium in your pressure cooker. A bundle of a dozen or more test tubes may be held together with a rubber band and placed upright in the cooker. When you have loaded the cooker, be sure to cover the cotton plugs with a "roof" to prevent condensation from falling on and wetting them. The "roof" may be a piece of paper or, better, aluminum foil. It is held in place by the rubber band.

Sterilization is considered complete after fifteen minutes of "cooking" under steam pressure. Allow the cooker to cool before opening it, for if you release pressure suddenly the tubed medium will boil over and wet the plugs.

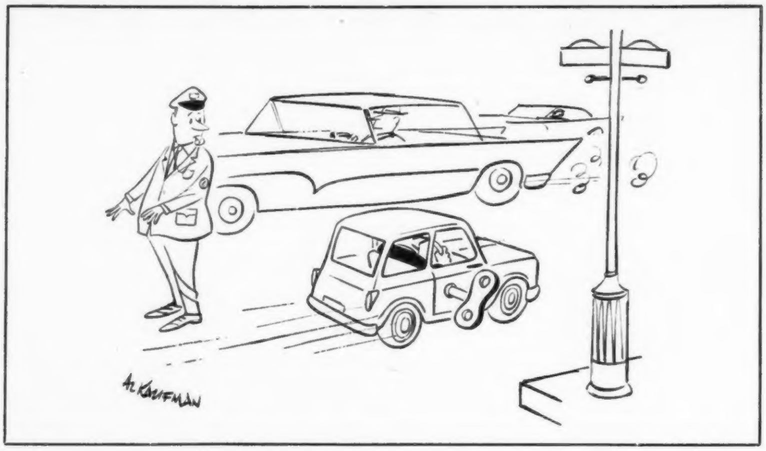
Remove the tubes from the cooker. Those containing two inches of medium should be allowed to cool in an upright position. Those filled to a 1-inch depth should be cooled in a slanted position, with the stoppered end about an inch above the other end. When the medium has solidified, place the tubes in a refrigerator for storage.

The Petri dishes, the glass atomizer, and other all-glass equipment can be conveniently sterilized in an ordinary kitchen oven. Each item should be tightly wrapped in a layer of newspaper and placed in an oven set for a temperature between 350° and 370° F. In about an hour the paper will show evidence of browning. It may then be presumed that the glassware is sterilized.

Developing micro-organisms

Place two or three test tubes containing two inches of medium in a saucepan of boiling water. Allow them to remain there until the medium is completely melted. Unwrap several Petri dishes and set them out, unopened, on the table. Light the alcohol burner.

Remove the cotton plug from one of the tubes. This should be done with a twisting motion while the tube is held at an angle to minimize possible contamination from the air. Pass the mouth of the test tube across the burner flame to sterilize it. Raise the cover of a Petri dish slightly to enable you to pour the melted contents of the



tube into the dish. Cover the dish quickly and tilt it around to distribute the medium in a uniformly thin film. Now set the dish aside to solidify. Prepare another dish or two in the same manner.

Secure cultures of micro-organisms by allowing the Petri dish to stand uncovered for about ten minutes. Depending on the drafts present and the dust in the air, a hundred or more invisible living organisms will have fallen onto the nutrient agar in that time. Replace the cover and invert the dish. It might be well to expose two or three dishes, each for a successively longer period of time. Store them in a warm dark spot for incubation. Within a day or two, colonies of micro-organisms will probably be visible to the naked eye on the surface of the agar. These should be incubated for several more days until the larger colonies reach a diameter of one to three millimeters.

Securing pure cultures

To transfer a single type of microorganism to a prepared Petri dish or test tube, you will need an inoculating needle. You can make one as follows: Hold the end of a piece of glass rod in a Bunsen burner flame or kitchen gas stove flame until the glass is softened. Take a four-inch piece of Nichrome wire in a forceps and insert the end into the melted glass. When the glass has cooled and the wire is firmly embedded, bend the free end into a small loop.

To transfer organisms from a particular colony, sterilize the wire loop of the inoculating needle by heating the loop in a flame until it is red. Hold the needle in the right hand. Lift an edge of a Petri dish cover just enough so that you can dip the loop of the needle into the desired colony. Then, as quickly as possible, pick up one of the tubes that was cooled in a slanting position. Remove the cotton plug from the tube, while grasping the tube in the crook of the little finger of the right hand. (The needle, meanwhile, is held between thumb and forefinger.) Pass the mouth of the test tube through a flame, then insert the needle into the sterile tube, touching the loop to the *far* end of the slanting agar surface. Pass the needle along the entire length of the sterile surface in one continuous motion. It is not necessary to press the needle into the agar.

Now flame the mouth of the test tube again, and replace the plug. Don't forget to sterilize the needle before putting it down. If you have worked carefully, you will find that when the tube is incubated you will have a pure culture of a single type of organism.

Discovering antibiotic-producers

When you have mastered the techniques of culturing and sub-culturing described above, you can begin to experiment. Select a Petri dish that has been exposed to air-borne micro-organisms for about fifteen minutes and then incubated for two or three days. One containing from thirty to fifty visible colonies is best for our purposes.

With the Nichrome loop, remove one of the larger colonies. Insert the loop in the sterilized water in one test tube. Shake the loop in the water to disperse the colony. This will produce a slightly cloudy suspension. Place one or two cubic centimeters of this suspension in the previously sterilized glass atomizer. Then carefully spray the mist from the atomizer onto the surface of the Petri dish from which the colony was selected and, if you wish, onto the surface of other colony-bearing dishes. Take care not to allow visible water droplets to form on the surface of the agar. A very few squeezes of the bulb will suffice to contaminate the agar over its entire surface. Replace the cover of each Petri dish so treated, invert the dish, and incubate it in a dark, warm place for two or three days.

During incubation, the millions of single cells in the atomized dispersion will begin to grow over the agar surface in the Petri dish — except where they may be inhibited by the antibiotic effect of one of the older colonies. When this happens, a "zone of no growth" will be clearly visible around the colony. Transfer micro-organisms from this colony to an agar slant tube using the method you have already learned. Incubate in a dark, warm place, and you will have a stock culture of your new antibiotic-producing strain of micro-organisms.

A good source of strains that produce useful antibiotics is the soil. (The micro-organisms that produce Aureomycin, Terramycin, and other "wonder drug" antibiotics come from the soil.) Add a "pinch" of soil to one of the test tubes containing sterile water. Stir and allow to settle. Now melt the agar in three test tubes and prepare to pour it into Petri dishes. Before pouring, however, allow the tubes to cool until they can be comfortably held against the cheek. Then dip your sterile Nichrome loop into the water and transfer a droplet to the agar in the first tube. After agitating and rotating the inoculated agar, remove a loopful of it and inoculate the second tube. Agitate the second tube, remove a loopful of agar from it, and inoculate the third tube. Then pour the contents of the tubes into separate sterile Petri dishes, cover, and allow to solidify. All this must be done quickly, before the agar has begun to harden.

The technique of using the three tubes is called "serial dilution." The first dish may contain so many organisms that the colonies will overgrow one another and make separation of a pure strain impossible. By taking a small amount from the first test tube and introducing it into the second, relatively few organisms are carried over. So fewer colonies will appear in the second dish. After three such dilutions, one or more of the dishes should have separate, single colonies. These can be experimented with, as described above.

When you have isolated a particularly powerful antibiotic strain, you can prepare a fine exhibit of its effects. To do this, culture organisms particularly susceptible to the antibiotic.

— Theodore Benjamin

On the light side

— Drawings by LoCurcio

Brain teasers

Iron overboard

A ship, loaded with scrap iron, is floating in a canal lock. What happens to the water level in the lock (asks physicist George Gamow in his recent, delightful book, *Puzzle-Math*) if the crew tosses all the iron overboard?

Multiplying ancestors

Every person now living has two parents, four grandparents, eight great-grandparents, etc. The number of ancestors doubles each time you go back a generation. It would seem, therefore, that the farther back you go in time, the greater the world's population must have been. Is this sound reasoning?

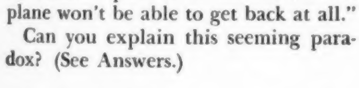
Airplane paradox

An airplane flies from city A to city B, then back to A again. When there is no wind, its average ground speed for the entire trip is 100 miles per hour. Assume that a steady wind blows from A to B. If the plane makes the same round trip, at the same constant motor speed, how will the wind affect its average ground speed for the trip?

Smith argues: "It won't affect it at all. The wind speeds up the plane on the flight from A to B. But on the return trip the wind slows down the plane by the same amount."

"That sounds reasonable," agrees Jones, "but suppose the wind is 100 miles per hour. The plane will go from A to B at 200 miles per hour, but its return speed will be zero. The plane won't be able to get back at all."

Can you explain this seeming paradox? (See Answers.)



A B C

Penny poser

Arrange three pennies on a smooth surface, as shown. Challenge anyone to move penny *C* to a position between pennies *A* and *B*, while observing the following conditions: *B* must not be moved from its position, and *A* must not be touched in any way.

Few people are likely to hit on the method, unless they recall that solid bodies are capable of transmitting a force without moving. Simply place the tip of your left forefinger firmly on top of *B*. Slide *C* toward it, releasing the penny before it strikes the right edge of *B*. The force of the blow will be transmitted to *A*, shooting it off to the left. You now have only to put *C* between the other two coins, and the trick is done.

Far or near?

The only clue at the scene of the crime was a pair of spectacles. Sherlock Dolmes held them a foot or two from his eyes. "Hmmm," he said. "The murderer was farsighted in his left eye, nearsighted in his right, with a bit of astigmatism in both."

"Great Scott!" exclaimed Matson. "How did you deduce that?"

"Elementary, my dear Matson. When a lens magnifies objects seen through it, it is a convex lens intended to correct farsightedness. When the lens diminishes objects, it is concave and intended to correct nearsightedness. And if objects change their shapes when you rotate the lens slowly around its center, you know the lens is for astigmatism."

Knowing these facts, you can tell at a glance through a person's glasses the kind of eye trouble he has.

Suspended rice

A popular trick among Hindu fakirs is that of plunging a dagger into a bowl of rice. When the fakir lifts the dagger, the bowl is raised with it. Oddly enough, there is no "gimmick." You can do the trick yourself with a glass jar, a box of uncooked rice, and an ordinary table knife.

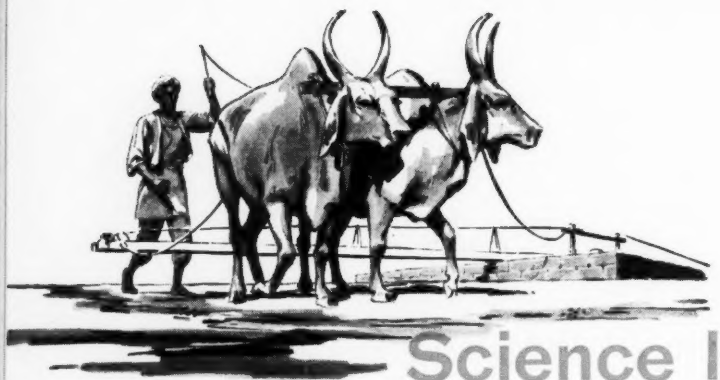
The jar must be wider than its opening. Fill it to the brim with rice, packing the grains down with your thumbs. Plunge the knife straight down into the rice. Pull it out and repeat, in a series of quick jabs no more than a few inches deep. With each stab, the grains pack more tightly. After a dozen or more of these short jabs, plunge the knife down as far as you can. If enough chains of rice grains wedge themselves against the blade and the top of the jar, you can lift the knife, and the entire jar will cling mysteriously to it! — GEORGE GROTH

Answers

IRON OVERBOARD: The water level goes down. While in the ship, the iron displaces an amount of water equal to its *weight*. At the bottom of the lock, the iron displaces an amount equal to its *volume*, which is considerably less water.

MULTIPLYING ANCESTORS: No. The fallacy here lies in forgetting that brothers and sisters have the same parents. Actually, the world's population has steadily increased.

AIRPLANE PARADOX: Smith is correct in saying that the wind increases the plane's speed in one direction by the same amount that it reduces the speed in the other direction. But he is wrong when he says the wind won't affect average ground speed. He forgets one point: *the length of time* the plane flies at each speed. As a result of the wind, the trip from B to A takes more time than the trip from A to B. So more time is spent flying at the slower ground speed. This means that the average ground speed for the round trip decreases. If the wind is strong enough, the average ground speed will drop to zero. In other words, the plane won't get back to A at all!



By E. H. Harvey Jr.

Science lends a hand

An attack on big world problems concerning food, disease, and power is being made by hundreds of scientists working in tiny villages of far-away lands

■ Throughout the world, in lands less developed than ours, scientists are helping people to help themselves. The work doesn't always fall under the heading of major scientific achievement. It's not meant to. Often, it's simply using science to solve problems with whatever means are at hand. But it accomplishes an important purpose indeed — that of making people healthier and happier.

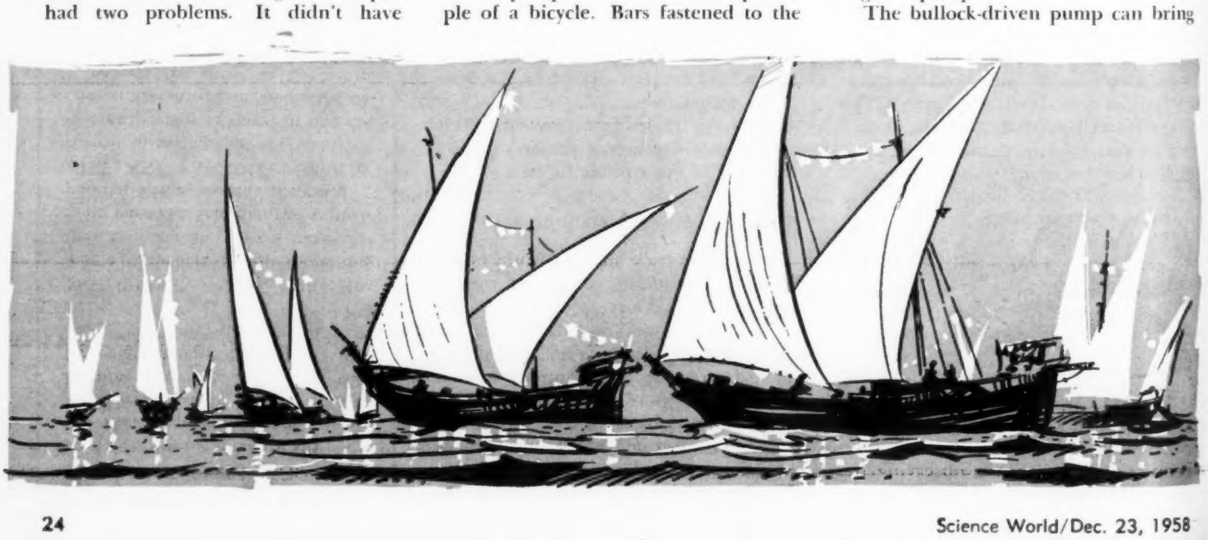
This being the season of "good tidings" and "good will toward men," it's an appropriate time to describe some of this work. So here's a kind of Christmas stocking of heartening science news from around the world:

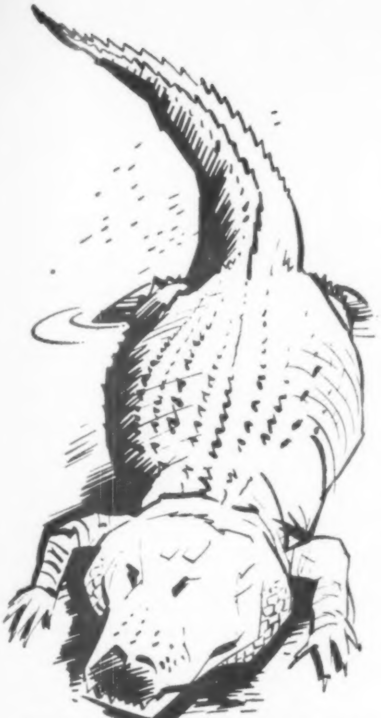
A- (for animal) power in India. Like most small Indian villages, Khanpur had two problems. It didn't have enough water for household use and for irrigation. And it needed electricity, which was too costly to bring to rural areas.

A United States engineer, Leigh Stevens, solved the problems in a novel way, using the best means available. He designed a special pump to bring up underground water. The pump is driven by bullocks, common work animals of the country. But it's more than a water pump. At the flip of a switch, it becomes a generator, converting bullock power into electrical power.

Several U.S. industrial firms, the Indian government, and the Ford Foundation financed the installation of the pump. It works on the principle of a bicycle. Bars fastened to the bullocks' backs are attached by a series of chains and sprockets to a vertical drive shaft. The bullocks move around the shaft at 2 revolutions per minute, but the series of chains and sprockets pushes the drive shaft rate up to 20 rpm. So far, this is very similar to the pedal-and-wheel action of a bicycle. The bicycle pedal turns a large sprocket, which is connected by a chain to a small sprocket on the rear wheel. As a result, the rear wheel makes more revolutions than the pedal. In the bullock-powered pump, however, there is still another chain-and-sprocket connection to the pump itself. This final connection ups the rpm to 150, the desired speed for turning the pump.

The bullock-driven pump can bring





up at least twice as much water as most pumps now used in Indian villages. And, equally important, every part of the pump can be manufactured in India, with available materials, at the moderate cost of $3,000. It will, of course, be a long time before enough pumps are installed in villages to make a real difference in the over-all standard of living in India. But a start toward plentiful water and inexpensive power has been made.

Less light, more fish, in Tunisia. Up until a few months ago, parts of the sea off Tunisia were lighted up like a city square. Night fishermen used long strings of powerful light bulbs to attract sardines and anchovies into their nets. But they don't any more. They now use one 500-watt bulb *under* the water, instead of up to twenty-four 500-watt bulbs *above* the water. And they're catching more fish. Most of the light from surface lamps was being wasted because it was reflected by the surface of the ocean. The surface also acts as a reflector when a lamp is submerged. So, with the new arrangement, very little light escapes from the water.

It was an Italian fisheries scientist, Captain Luigi Farina, who showed these fishermen how to catch more fish with less wattage. He was working on an assignment for the United Nations' Food and Agriculture Organization (FAO). The captain also introduced a modern fishing technique: the use of an electronic echo-sounder to locate schools of fish. Using the echo-sounder, fishermen can make sure there are fish around before they drop anchor and switch on their lights.

Fishermen aren't the only ones who benefit from bigger catches. Fish are a primary source of protein, and protein is probably the world's number one nutritional lack. For this reason, there are literally hundreds of UN projects designed to increase fish-catching and fish-eating. These range from modifying canoes in Ghana to make them more suitable for fishing to the development of a palatable fish flour in Thailand.

Skinning crocodiles in Gambia. Natives in this West African land may soon have a thriving new industry, thanks to a recent visit by an FAO hides-and-leathers expert. The industry: crocodile skins. Crocodiles are numerous in many rivers and creeks in Gambia. But the natives hunt them only occasionally, and then usually for their meat, not their skins. The natives know very little about proper skinning and curing techniques. So the skins they do sell bring much lower prices than they should.


Illustrated by Peter Burchard

The hides-and-leathers expert, G. C. van Hoorn, found that the natives did practically everything wrong. During skinning, they usually threw the crocodile in the sand, dirtying and scratching its skin. But when he pointed out that it would be better to put mats and leaves underneath the crocodile, the natives willingly did so. Another mistake they were making was slitting the skin on the belly of a crocodile in order to peel off the skin. It's easier to do it that way because the belly is softer, but the belly is also the most valuable part of the skin. The leathers expert convinced the natives that it would be better to slit the back.

Adequate curing is a much more difficult problem. Ideally, the best way to cure a skin is to use a great deal of salt. But salt is tremendously expensive to the natives. Skins cured with insufficient salt soon dry out and become worthless. And more primitive methods of curing skins, such as drying them in the sun or shade, are even less satisfactory. The skins more often than not begin to rot before the curing is complete. But G. C. van Hoorn isn't admitting defeat. He's trying to persuade Gambian officials to remove the import duty on salt — and make up for the lost revenue by exporting high-quality crocodile skins.

Slow death in Japan. Though more than 100 million people still suffer from schistosomiasis, this slow-killing disease has been conquered in Nagatoishi, a farm village on the Japanese island of Kyushu. Where the villagers could once expect twenty-five to thirty acute cases a year, there is now only an occasional case reported.

The disease is caused by a tiny parasitic worm, the schisto. It bores through the skin, attacks the liver, then multiplies and spreads to the intestines, bladder, and lungs. Advanced stages of the disease are marked by extreme lethargy, nausea, and eventual death. Since the schisto's eggs hatch in water, the flooded fields and irrigation ditches of rice farms make a perfect breeding place for them — to the great misfortune of millions of rice farmers throughout the Orient.

The successful campaign against schisto at Nagatoishi was the joint work of a U.S. Army medical team, Japanese scientists, and scientists of the Monsanto Chemical Company. Colonel George W. Hunter, head of the Army medical team, had made a

thorough study of the schisto parasite's life cycle. He knew the parasite was particularly vulnerable at one stage. Its larva had to find a living snail to grow in. If it didn't find a host snail within twenty-four hours, the larva died. What he needed to wipe out the schisto parasite, Colonel Hunter concluded, was a chemical spray that would kill the snails but be completely harmless to men, livestock, and crops.

A compound named Santobrite turned out to be the most promising chemical for this purpose. Monsanto, which made the chemical, gave Colonel Hunter's program — free of charge — enough Santobrite to run a comprehensive test. The test was successful. A start had been made toward the control of schistosomiasis.

Mad wolves in Iran. A new type of anti-rabies serum recently helped save the lives of twelve Iranians who had been slashed and bitten by a rabid wolf. An unlucky thirteenth victim died. But if only the old anti-rabies vaccine had been available, at least six or seven would surely have died. This dramatic incident marked the first advance in rabies prevention since 1885. It was then that Louis Pasteur developed a vaccine that proved successful in some rabies cases. Now, when the vaccine and serum are used jointly, it appears that few lives will be lost.

It was not just luck that the new serum was available in Iran. Medical scientists of the World Health Organization (WHO) had kept it there since 1950 for use in such an emergency. At that time, the serum's effectiveness had been definitely proved in individual cases. But before it could be released to the world, the doctors had to have more convincing proof. They could do nothing but sit and wait for a rabid wolf to attack enough people to make a statistically indisputable test. Iran seemed the most likely place to wait: prowling wolves are everywhere in the Iranian hills, and the rabies risk is high.

In an attempt to provide every area of the world with up-to-date information on the prevention and treatment of rabies, WHO doctors keep in close contact with all rabies research activity. New research findings on other virus diseases — polio, smallpox, yellow fever, trachoma, influenza — are similarly checked and distributed by WHO.

Potato killers in Mexico. Late blight is one of the most destructive and notorious vegetable diseases. When it strikes potatoes, it not only kills the foliage but rots the tubers in the ground and in storage. When it struck the Irish potato fields in 1845 and 1846, hardly a potato was left in all Ireland. More than one million people died in the famine, and more than one and a half million had to leave the country.

For the past several years, scientists working for The Rockefeller Foundation have been waging an all-out war against late blight in Mexico. They've concentrated particularly on the Valley of Toluca. There, late blight takes such heavy tolls that potato farming is virtually impossible. The scientists battled the blight with countless chemical sprays and with many strains of potatoes, both natural and artificially developed. Each method was found lacking in some respect. Potatoes resistant to the blight were developed, but their taste or consistency or color proved commercially unsatisfactory. One kind of Mexican wild potato had a very high resistance to late blight, but it verged on the inedible. It was this wild potato, however, that eventually became the parent of the Erendira potato — a tentative answer to late blight.

In 1958, an experimental planting of Erendiras showed good resistance to late blight and, when harvested, had excellent commercial qualities. Rockefeller Foundation scientists aren't completely satisfied with the Erendira. They want to find a bigger, more resistant strain. But farmers are beginning to plant potatoes again in the Valley of Toluca. And soon potatoes may no longer be a luxury on Mexican dinner tables.

Yours for the asking

The Civil Jet Age — A Look at Tomorrow explains the basic physics of jet flight, defining in simple terms the principles of "action," "reaction," and "thrust," and summarizes the policing of airlanes by the use of the Air Transport System. The second part of this brief pamphlet, which is published by the Air Transport Association of America, delineates some problems faced by commercial airlines — i.e., regulatory practices, cost of operation, etc. Check No. 12231.

Dangers of water pollution are meticulously detailed in *Protecting Our Living Waters*, a two-color booklet prepared by the National Wildlife Federation. Topics include: definition of types of pollution, how pollution endangers health, how pollution diminishes food supply, effects of pollution on industrial growth, what is being done to decrease pollution hazards. Also: a suggested plan for initiating a pollution abatement program in your community and a list of inexpensive material for additional reading. Check No. 12232.

E. I. du Pont de Nemours & Company has published a colorful 36-page booklet that provides a virtual history of man as reflected by his technological advances. *The Story of Technology* contains many illustrations of up-to-the-minute industrial, medical, and research equipment. Of use, too, in social studies classes: sections on "The Technical Ages of Man" (Stone Age to the beginnings of modern science), "The Man of the Renaissance," and "The War on Social Evils." For this booklet, Check No. 12233.

Should You Be a Doctor? will be helpful to students who are considering a career in any phase of medical science. Dr. Walter C. Alvarez describes traits essential to study in this field. The pamphlet is from the career series published by the New York Life Insurance Company. Check No. 12234.

Check your choice, clip coupon, and mail to: **Yours for the Asking, Science World, 575 Madison Avenue, New York 22, N. Y.**

☐ **12231 The Civil Jet Age** ☐ **12233 The Story of Technology**

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See also: page 2

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PLEASE PRINT

Joseph A. Ratchford of Elmsford, New York, writes:

What is quicksand and what is it caused by?

Quicksand is simply loose, ordinary sand mixed with water. Clay or other material under the sand keeps the water from draining off. The water lubricates the smooth, round grains of sand, making them slippery. When a weight pushes down on the quicksand, grains slide aside; the weight sinks.

Quicksand is usually found on flat shores, particularly near the mouths of rivers. Here, water from tides or currents is likely to collect in a bed of sand. People seldom recognize quicksand as such, which makes it dangerous. One of the most spectacular incidents involving quicksand happened in 1875 in Pueblo, Colorado. A whole train was swallowed up by it. Though workers probed down to a depth of fifty feet, they couldn't reach the train.

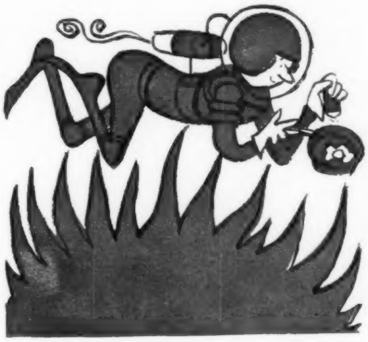
When engineers have to work in quicksand, they sink hollow cylinders (caissons) into it. Or they may congeal the sand.

Stanleigh Phillips of Virginia Beach, Virginia, writes:

Why does rubber bounce?

Rubber bounces because it is elastic. And its elasticity comes from the shape of its molecules. (A molecule is the smallest particle of a substance that has the same properties as the substance.) The rubber molecule consists of hydrogen and carbon atoms. As molecules go, it is a giant one. It has many parts (scientists don't know how many) that are hooked together in a chain. This chain is coiled somewhat like a spring. And like a spring, it can be stretched or compressed, but goes back to its normal shape when the force acting on it is removed.

A rubber ball contains millions of these molecular springs. When a ball is thrown against a wall, the force at which it hits compresses the molecules. As they spring back to their normal shape, they push against the wall. Result: the ball bounces.



William Smith of Ottumwa, Iowa, writes:

How hot is the sun?

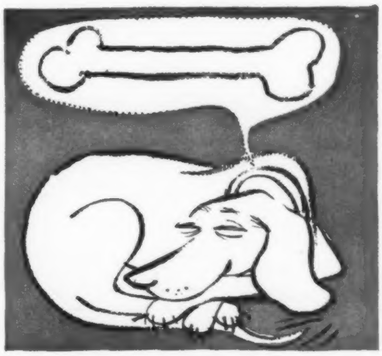
That depends on what part of the sun you're talking about. The temperature of its surface is about 10,300°F. From its surface to its center, the sun gets hotter and hotter. At its center, where atomic fires rage, the temperature is estimated to be from 35,000,000° to 50,000,000°F.

Martin Siravo of Cranston, Rhode Island, writes:

Do dogs have dreams?

It's too bad the dogs can't answer that question themselves, because nobody knows for sure whether dogs dream. A sleeping dog sometimes twitches, whimpers, barks, wags its tail, and pumps its legs as though chasing a rabbit. So there's a strong possibility that dogs do dream. But better evidence will have to be gathered before a reasonably certain answer can be given.

Drawing by Woolhiser



Andrew Eells of Stone Harbor, New Jersey, writes:

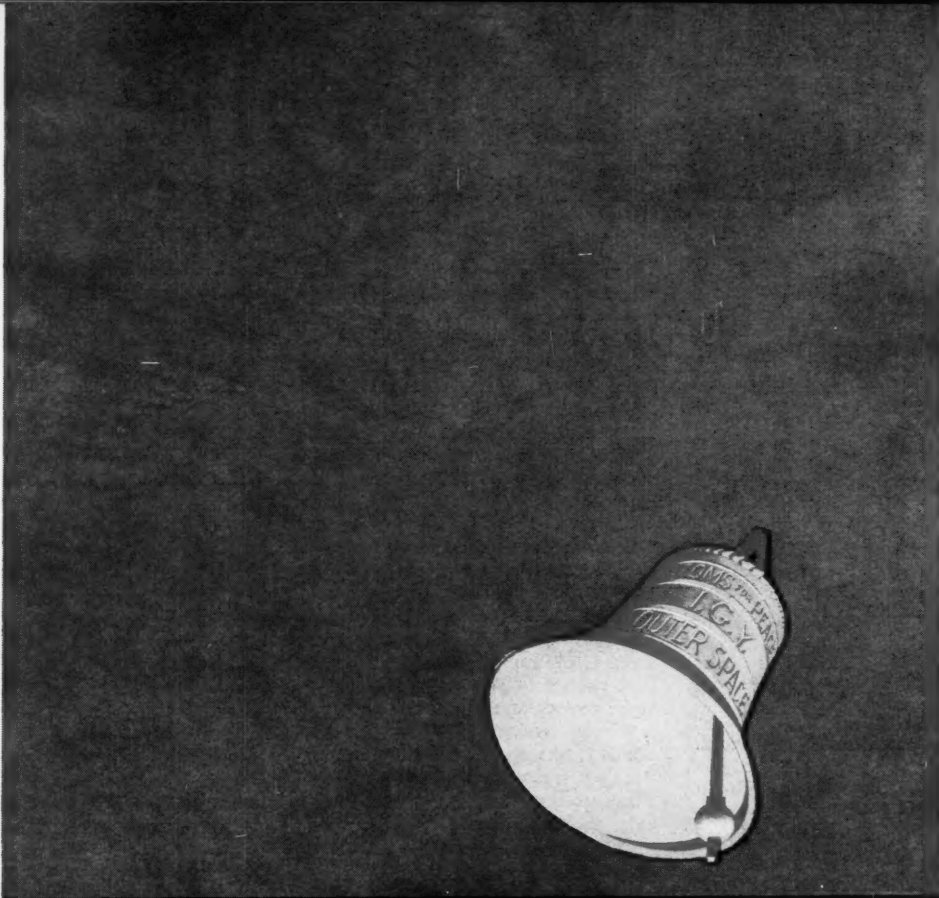
Has a metal been perfected yet that can withstand re-entry into the earth's atmosphere?

At least two metals are now used for re-entry. The nose-cone shield of the Thor intermediate ballistic missile is made of beryllium, a rare metal. And the nose cone of the Atlas intercontinental ballistic missile is tipped with copper.

As you know, a missile is shot upward to the fringes of space. On the way up, its various stages burn out and drop away. Finally, the nose cone, carrying the warhead, plunges downward toward the target. It re-enters the thicker part of the earth's atmosphere at a tremendous speed. The heat from air friction builds up to a point where the cone would ordinarily burn up. But scientists have developed ways of keeping it from doing so.

Beryllium and copper have two properties that make them useful in nose cones. They are strong enough to withstand aerodynamic stresses and they transfer heat at a rapid rate. When these metals are used in nose cones, their surfaces don't get as hot from air friction as would the surfaces of most metals. Reason: the heat is carried away before it builds up to destructive temperatures.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.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OUTER SPACE

How to do it

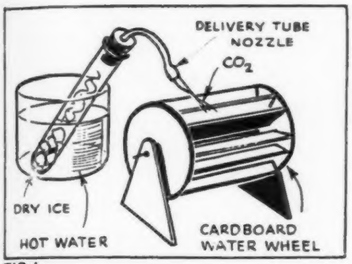


FIG. 1

Carbon-dioxide gas turbine

In general science classes, when transformations of energy are studied or when ways of doing man's work are developed, the turbine appears as one of the machines involved. The steam turbine is fairly easy to demonstrate. However, the gas turbine — as used in turbojets, in some large turbine locomotives, and in some new powerhouses — presents a different problem.

The general principle behind this turbine can be illustrated by using carbon dioxide supplied by dry ice. A lightweight turbine wheel is made from manila-folder stock. Its parts are cemented together with model-airplane cement. A wire serves as the shaft. The wheel should be about two inches in diameter and about two inches wide. The carbon-dioxide generator is a small Pyrex flask or a Pyrex test tube into which dry ice is placed. Do not pack it tightly. Use loosely held lumps. (WARNING: handle dry ice with gloves.) Drivers of ice cream trucks who deliver to school cafeterias can arrange to get dry ice for you from the ice cream plant.

Fit a stopper with a delivery tube and a glass nozzle, as in Fig. 1. Then insert the test tube into a jar or can of hot water. Direct the escaping carbon dioxide at the blades of the turbine. Don't worry if the stopper pops off occasionally: this happens. You might also want to use a toy pinwheel as a turbine by directing the jet of carbon dioxide at the pinwheel blades.

Bacteria incubator

In general science and biology units on bacteria, it is sometimes necessary to incubate Petri dishes that contain nutrient agar and that have been inoculated with dust, water, or other agents. A simple incubator can be made in a hurry by following the plan in Fig. 2.

First, take a wooden box about 12 inches high, 8 inches wide, and 20 inches long. (These dimensions are not critical.) The box should have an overlapping cover as shown in Fig. 2.

Second, drill a hole in the cover to take a cork or rubber stopper that carries a laboratory thermometer. Then drill holes to support the dowel rods of wood that will support aluminum cake pans or heavy foil pans. The Petri dishes are placed in these pans. On the bottom left of the box there is a block of wood. This serves as a base to which you fasten a thermostat and a porcelain-base, standard socket. Insulate the terminals of the socket with tape. The thermostat and socket are connected in series with electric-lamp wire to a plug, as indicated. Place a 100-watt bulb in the socket and place an inverted tin can over the lamp to prevent the light from reaching the bacteria.

Adjust the thermostat to maintain body temperature (98.6 F.) or just slightly higher. The thermostat can be of the ether-wafer variety sold by poultry supply houses for use in chick incubators, though other types of thermostats that work in the same temperature range may also be used. Incubate the Petri dishes for a period of twenty-four hours.

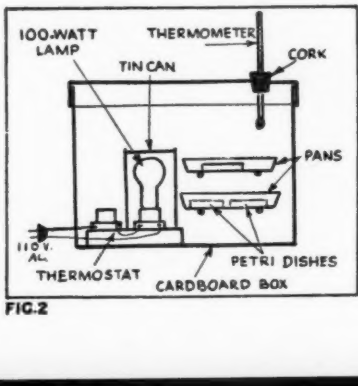


FIG. 2

Controllable-rate, soda-acid fire extinguisher

The soda-acid fire extinguisher is demonstrated in almost every chemistry and general science class. Since the model described here employs vinegar as the acid, it may be safely used by students. An added advantage: two bottles are used; this avoids the kind of demonstration in which all the chemicals are placed in one bottle and therefore tend to work too rapidly, frequently forcing the stopper off.

Drawings courtesy of Popular Science

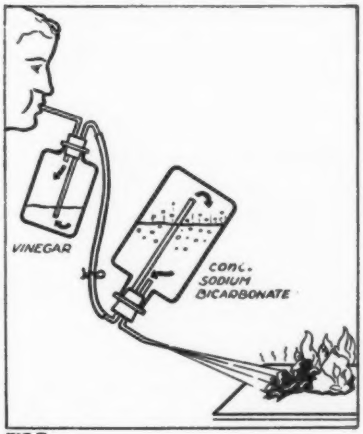


FIG. 3

Two bottles fitted with two-hole stoppers are required. The upper bottle, as in Fig. 3, has a short tube into which air is forced by mouth. (This tube should be fire-polished to prevent cutting the lips. As an additional safety device, it can be fitted with a short length of rubber tubing as a mouthpiece.) The other tube extends to the bottom, and the bottle is partly filled with vinegar. The second bottle has the same stopper arrangement, with the longer tube connected to the outlet of the vinegar bottle. A pinch clamp or a spring-type

clothespin is used on the rubber tube connecting the two bottles. The outlet tube is one that has a right-angle bend and a narrow spout. (A second short rubber tube fitted with a medicine-dropper tube may be substituted.) The second bottle contains a concentrated solution of simple sodium bicarbonate.

On some fireproof surface make a very small paper fire. Use one hand to direct the lower bottle: hold the vinegar bottle with the other hand. Open the pinch clamp and blow into the vinegar. As vinegar reacts with the sodium bicarbonate, carbon-dioxide gas is released.

The gas forces water out of the lower bottle onto the fire. The harder you blow, the faster the rate of carbon-dioxide gas formation and the greater the pressure of the extinguisher stream in the direction of the flame.

Safety devices for the science classroom

In *A* of Fig. 4, a test tube of liquid is being heated. Note that the liquid is heated near the top of the surface. This prevents steam from forcing liquid out of the tube and across the table top as frequently happens when a test tube is heated at the bottom.

With certain experiments in combustion that take place inside bottles or cylinder, there is the hazard of the glass walls shattering. If the outside of the bottle or cylinder is coated with model-airplane cement and then wrapped with a layer of cellophane while the cement is wet, you have made a simple type of safety glass. See *B* in Fig. 4. Even if the bottle shatters, the glass will not fly. Another way to do this is to wind a layer of Scotch Tape around the bottle from top to bottom.

It is dangerous to heat certain volatile liquids with a flame. A safe method is shown in *C* of Fig. 4. Place the liquid in a flask or test tube which is heated by hot water placed in a metal or glass container. If inflammable, no sparks or flames should be present.

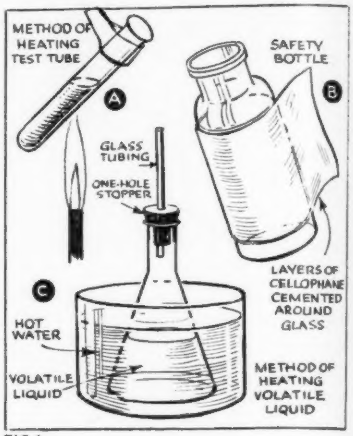


FIG. 4

Science teacher's question box

What can I use to keep animal blood from coagulating in a container? — B. L., Watertown, Mass.

Add a solution of sodium citrate. Close the container with absorbent cotton.

How can I observe scintillations due to radiation from decaying atoms? — R. W., New York, N.Y.

A radium watch dial can be observed with a 10-power hand lens or a low-power microscope in a dark closet. It will take about 15 or more minutes for the eyes to become accustomed to the darkness.

How can I successfully keep plants growing on a classroom window sill while the radiators are going full blast? — B. H., Northridge, Calif.

The solution is a pebble tray. This is a metal trough filled with clean quartz pebbles or with vermiculite pebble-size bits of house insulating material. Fill this tray with water, and stand the potted plants on the pebbles in the water. The plants will not be overheated and will not dry out. Be sure to keep the water level up.

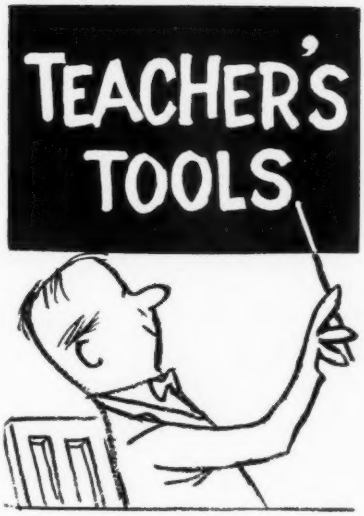
In connection with vitamins, hormones, and antibiotics, one often hears of substances effective in dilutions of one part per million or even of one part in ten million. How can one obtain such extremely small dilutions? — R. P., Miami, Fla.

You can make a dilution as small as you wish in this way: Suppose you dissolve one gram of salt in 100 grams of water. You will have one part per 100 solution of salt. Now, pipette off one cc. of this solution into an empty 100 cc. graduate. Then fill the graduate to the 100 cc. mark with water. You will now have a one part per 1,000 solution of salt. The process can be continued in this way to get solutions of one part per 10,000, 100,000, and so on, even to one part per several billion.

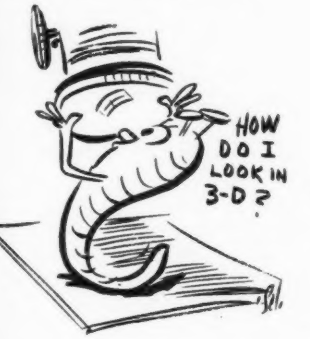
How can I make a quantitative demonstration of the reduced energy delivered by slanting rays of the sun during the winter in the temperate zone? — J. J., Bronx, N.Y.

Use a strong light source such as a projector, and direct it at a geography globe whose axis is tilted away from the light source. Hold a photographic exposure meter at the equator and at the 70th parallel. Compare the readings. The exposure meter cell must be parallel (actually tangent in this case) to the surface of the geography globe at the positions being tested. The reading is much lower in the temperate zone.

Questions from teachers will be answered here, as space permits. Send questions to: Science Teacher's Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y. We regret that questions cannot be answered by mail.

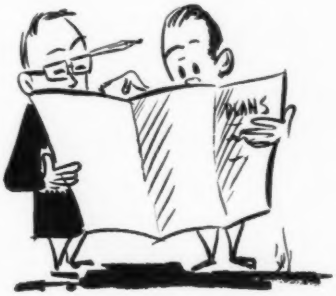


BAUSCH & LOMB OPTICAL COMPANY suggests the use of its Stereomicroscopes for three-dimensional magnifications of leaves, rocks, insects, spider webs, flower buds, soils, and a host of objects of varying opacity. The B&L stereoscope, with its right-side-up, unreversed image, opens up new worlds for students as they probe natural phenomena and other forms of matter not usually observed in this dramatic new way. All models can be supplied with either Huygenian or widefield eyepieces and a choice between conventional and reversed bodies. For a demonstration of the Stereomicroscope in your own classroom, write directly to Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N.Y. (*Note: Do not use coupon for this request.*)



WILKENS-ANDERSON COMPANY has earned a reputation as Semi-Microchemistry apparatus specialists. For some years now, authors have looked to this apparatus-maker for the specialized and unique items needed to complement their texts and laboratory manuals. Two Semi-Micro items currently featured by Waco include hand-finished spatulas and the Weisbruch-Waco reagent bottle tray. Free brochures available include "Semi-Micro Apparatus, Vol. I," and "Listing of S-M Apparatus According to Semi-Micro Laboratory Exercises in High School Chemistry," Fred T. Weisbruch. (*For your copies, check No. 1223A.*)

THE KEWAUNEE MANUFACTURING COMPANY, producers of a complete line of standardized and custom-built scientific laboratory furniture (wood and steel), offers consultation services without charge, including drawings for modern science teaching. Kewaunee field engineers throughout the country are available at all times to assist in the planning and building of school laboratories especially designed for individual teaching needs. The company offers school administrators, science department personnel, and architects a series of helpful catalogues, including one telling the story of Kemrock, laboratory bench working surface, and one giving details on laboratory fume hoods. (*Science people planning to remodel present facilities or construct new classrooms should check No. 1223B for their copy of Kewaunee's New Planning Manual for Educational Science Laboratories.*)



LEEDS & NORTHRUP COMPANY offers an interesting historical pamphlet, "Measuring Instruments." The booklet, a reproduction of an American Newcomen Society lecture by Dr. I. Melville Stein, L&N president, not only tells the story of a pioneer instrument-maker, Morris E. Leeds, but relates the fascinating history of such popular and well-known instruments of today as electronic recorders and potentiometers. Dr. Stein also discusses automatic controls, electric furnaces, and the role of research in producing instruments. (*For your copy of the Newcomen lecture, check No. 1223C.*)

Modern references and textbook 'tools'

Experimenting in Physical Science, by Allen D. Weaver, Ph.D., Associate Professor of Physical Science, Northern Illinois University, and James F. Glenn, M.S., Chairman, Department of Science, State Teachers College, Salisbury, Maryland, 1958. William C. Brown Co., Dubuque, Iowa.

Anatomical Atlas, Revised and Enlarged, by Maud Jepson, 29 pages, 1958. Rinehart and Co., Inc., 232 Madison Ave., New York 16, N.Y.

Behind the Sputniks, A Survey of Soviet Space Science, by F. J. Krieger, 1958. Public Affairs Press, 419 New Jersey Ave. S.E., Washington 3, D.C.

Analysis of Research in the Teaching of Science, July 1955-56, by Ellsworth S. Obourn, Specialist for Science, 1958. U.S. Govt. Printing Office, Washington 25, D.C.

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Shop talk

A pleasant and effective review game

Since the closing of a chapter, a unit, or the work of a quarter, semester, or the whole year each call for a review or a "clinching" exercise, why not make it a game? writes Sister M. Callista of St. Mary Convent, Wayne, Michigan.

Here is one that creates enthusiasm by competition. It's also one that is easily scored.

A few days before the game, students are told to prepare a set of twenty-five slips, each with a different question on the topic assigned. They are to write the answer after each question.

An easy way is to write the questions and answers on ruled paper, leaving three blank lines before beginning the next question. The slips are cut apart on the middle line. If slips of equal size are desired, printers' ends can usually be obtained, cut to size on the paper cutter, and given to students for writing the questions.

Before the game begins, the class is divided into groups. The groups need not be equal, since each student puts in twenty-five questions (or the number assigned).

The slips of each group are thoroughly shuffled and placed face down in the center of the table. (If tables are not available, two pairs of students face each other across the aisle. One player holds a box containing the slips to be used; the missed ones are dropped to the floor.)

When the game begins, the first player draws a slip and asks the question of the second. If the second answers correctly, he keeps the slip; if the answer is incorrect, the slip is put aside. The second player then draws a slip, asking the question of the next player. This goes on till all slips are drawn. The slips must be drawn in turn.

In this way each player has a chance at twenty-five questions. The slips he holds at the end readily tell his score, for each one counts 4%.

The teacher may make up his own questions, typing a set of fifty, seventy-five, or one hundred questions with answers and duplicating them on heavy paper as many times as he has groups. This, of course, insures that every important item is included; but it does not give the drill that students' questions do, since certain ones are repeated and often in different words — another advantage.

Balloon-saver

Howard I. Jump, science teacher at Plainfield (N.J.) High School, offers the following time- and money-saver:

Most science teachers know how to show that air has weight by suspending two identical, air-filled balloons on a meter stick so that they exactly balance each other; letting the air out of one balloon, of course, makes the inflated balloon go down.

Although a little less dramatic than the pin-prick method of letting out the air, the following method has two advantages: you can use the balloon over again, and time is saved because there are no knots to fuss over.

Simply fold a two-inch square of paper in half; fold it again in half, in the same direction; then fold it in half at right angles. With a paper clip, fasten this folded slip over the folded neck of the air-filled balloon. And there's your time- and money-saver!

We hope you'll consider "Shop Talk" a combination teachers' room, seminar, and conference round table — a meeting place where all good science teachers can come to the aid of one another by speaking their minds and sharing their experiences. Won't you send us news of unusual classroom experiments, problems, and/or triumphs?

Payments of twenty-five dollars will be made to contributors whose material is used in "Shop Talk." The editors regret that they cannot acknowledge or return unused contributions.

Please send your contributions to this address: Science World Shop Talk, 575 Madison Avenue, New York 22, N.Y.

Gold key requests

Are you planning any kind of awards-recognition at the end of the first semester? If so, now is the time to enter your request for the gold keys inscribed with the word "Science" that SCIENCE WORLD offers its teacher subscribers. These keys and their accompanying certificates are available ON REQUEST only. They should be requested according to this scale:

Student orders	Keys
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and so on, for as many student copies as you have ordered.

The keys may be awarded at your discretion to whichever student you wish to encourage with special recognition. Teachers who request keys at the end of the first semester may also request them at the end of the second semester.